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APPROXIMATIONS AND APPROXIMATION PROCESSES.*

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Introduction. A large number of the processes used in mathematics, at all stages, are essentially processes of approximation. Probably the most widely known of these is the ordinary process for extracting square roots of numbers. One less usually recognized as an approximation process is ordinary measurement of length, area, or any similar continuous quantity. While these processes form a very large part of the subject-matter usually taught in the elementary schools, they would seem to be absolutely misunderstood by many teachers and by many writers. It is the purpose of the present paper to discuss briefly the elementary phase of this subject in its application to secondary and primary instruction, and to draw lessons of direct influence upon our teaching.

The writer is not one to urge the introduction of delicate distinctions and difficult arguments into elementary teaching; if difficult questions are broached in what follows, it is not because of any desire of the writer that these questions be introduced, but it is rather because these topics are actually being taught in many of our schools at present, from a standpoint so fallacious as to merit their eradication in cases in which no practical benefit will result; while, on the other hand, many very useful substitutes are ready at hand, far simpler than the false doctrines of our popular text-books, and far more useful.

Time was when the effect of modern knowledge was not felt in questions of elementary character, when teachers were content to consider their subject-matter solely from the standpoint of the elementary student; that time has passed. The teacher of to-day realizes that he must study beyond the student, that he must

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consider the topics of elementary instruction in the light of knowledge beyond the range of the pupil to whom instruction is given, and that a statement or process is not correct unless it stands the test of such consideration. Some of the following remarks are not made for direct use in the class room, but rather for that indirect use which comes from fuller comprehension of the basis upon which the elementary instruction stands. We shall draw a distinct line between what is intended for actual instruction, and what is purely pedagogical and scientific reasoning directed toward the drawing of conclusions. In most instances it will be the conclusions, not the arguments by which we reach them, that will directly affect class room work.

The Nature of an Approximation. Approximations are essentially of two kinds: (a) those which arise through observation, in which the error is caused by the lack of precision of our instruments and of our senses, and in which there is a bound to the exactness which we can attain; and (b) those which arise in a mathematical process, in which the error is caused by the fact that the process would require an infinite number of steps, of which we can perform only a few, and in which there is no bound to the exactness which we can attain.

Approximations of the first kind are so ordinary as to deserve little comment, except from a pedagogical standpoint. It is one of the most important lessons that a child can learn in the school that the quantities with which he will have to deal in actual life are not to be accurately stated, as are the quantities usual in the text-books of to-day. But this lesson, important as it is in the development of common sense in the application of mathematics, is seldom learned in school. Few problems are assigned in which the inexactness of measurements is recognized; such problems should be given. Few problems are given which involve the necessity for finding the effect of an error; such a problem as the following: "How nearly accurate must the measurement of the side of a square be made in order that the computed area shall be correct to within one square foot, if the side of the square is a little over ten feet long?" The answer to this problem is about ½ inch. Such problems will improve the conception of actual work very materially. Or again, "In selling a bolt of cloth 50 yds. long, how carefully must the measurement of each yard be made in order that not more than 2 ft. be lost?"

Another lesson to be learned is the futility of carrying mathematical calculations based on observed data beyond the degree of accuracy of the data themselves. This should constantly be impressed by the teacher, and work carried beyond a reasonable limit of exactness should be condemned (as a waste of time) as sharply as work which is not sufficiently exact. Even a long division should not be carried beyond the reasonably "significant" figures. As an example, in a problem requiring the number of bolts of wall-paper required for a given room, the pupil should not be allowed to express a fraction of a bolt; and in other instances, it should be expected that he have a rational idea of what reasonable accuracy means. It should be noticed that the question of significant figures is not a question of decimal places, though the two are often confused. Thus the number of significant figures in $3.81\pm \div 2.47\pm$ is the same as in $3.81\pm \div 247\pm$ though the number of decimal places is different. It is the ideas which I have just mentioned which serve as a connecting link between approximations of the first kind, observational, and approximations of the second kind, mathematical. For, were it not for the fact that ordinary life furnishes and demands only approximate statements of quantities, a mathematical process which furnished only approximate results would not be a useful one. As a matter of fact, of course, an approximation process is as useful as an exact process. To this we shall recur.

The nature of an exact (or mathematical) process of approximation is readily understood, but the common presentation in text-books is not always trustworthy. The difficulty in a mathematical approximation usually arises not so much in the process itself, as in the question as to whether or not the quantity to which we wish to approximate is really itself defined. In order to give an illustration of the process itself, let us take an instance in which there is no question of lack of definition. Such an instance is the reduction of $1/3$ to decimal form. The quantity to be approximated is certainly defined, it is $1/3$. We show that we can write a decimal which (together with all which follow) differs from $1/3$ by less than any desired amount. It is important to notice that the desired degree of correctness must be stated first; the decimal which attains this degree of exactness can thereafter be mentioned. Essentially this problem contains

the principle of all mathematical approximations: It is to be noted that:—

(1) The quantity to be approximated to must be itself defined.

(2) There must be a process of determining an infinite number of approximations to the given quantity.

(3) It must be possible to select an approximation which (together with all which follow) differs from the given quantity by less than any preassigned amount.

The Value of an Approximation Process. The value of approximation process depends vitally upon the fact that human observations are open to error, and that therefore approximate results are all that are practically necessary. In order to serve its ends thoroughly, however, a mathematical process must be capable of being pushed to any degree of exactness whatever, since the process may be applied in different problems in which the degree of accuracy required may vary widely. Even this need, however, is limited to a certain degree. The value of π, for example, can be found to any number of decimal places required. As a matter of fact, its value has never been estimated beyond 707 decimal places, and no calculation has ever been performed in which the degree of accuracy actually required for π was anything like as great as this number of decimal places would represent. Nor is it probable that any calculations will ever require π to one hundred decimal places; even fifty places would suffice to compute, from the radius, the volume of the sphere which encloses the whole solar system to within a fraction of the volume of the smallest known microbe.

Thus, while not here recognizing as a mathematical approximation process any process which fails to reach any desired degree of exactness whatever, it is well for us to keep in mind that other approximations may have all the real practical value of a mathematical approximation. Again, in order to be of practical service, it must be possible to estimate (at least an upper bound of) the error made in any given approximations. Unless this can be done, the process itself is open to grave objection, since there would be no way of telling when the desired degree of correctness was attained.

The student should invariably be given some notion of the degree of accuracy represented by the approximations he is

obtaining, and he should not be allowed to use approximate values (e. g., of π or of $\sqrt{2}$) to more than a reasonable number of places. Thus the use of the common value of 3.1416 for π in the computation of the volume of a quart measure, for example, is absurd, for the tin would have to be cut to within about one ten-thousandth of an inch of the computed value of its dimensions in order that the computed figures should have any significance.

Approximation Processes in General. Any process which has the characteristics mentioned above is recognized as a worthy mathematical process. In fact, even for theoretical purposes, such processes are always, without exception, absolutely legitimate, if the process is not abused by the introduction of unwarranted assumptions. To make this quite clear, the writer will state the preceding characteristics in mathematical language.

Given a constant k, which is defined, then there is an approximation process for finding k in terms of desired forms if a set of numbers

$$a_1, a_2, \ldots a_i, \ldots$$

of the desired kind are known, such that

$|a_i - k|$ is less than p whenver i is greater than N where p is first assigned, and then N is found. To those who are familiar with infinite series, it will be clear that we have to deal here with the infinite series

$$a_1 + (a_1 - a_2) + \ldots + (a_{i+1} - a_i) + \ldots,$$

and that the sum of this infinite series is k. In fact, this is, to my mind, the best way of presenting the subject of infinite series to a young student. If it were generally recognized that there is no essential difference between the question of numerical approximations and the topic of infinite series, it would tend to increase materially the respect in which approximation processes are held, and it would do away with a great deal of nonsense which is frequently heard and frequently printed, concerning both of these subjects. This remark is made, however, for the consideration of the teacher, and it should affect his class room work, if at all, only indirectly.

Again, it is true that

$$\lim_{i=\infty} (a_i) = k$$

that is, the given quantity is the limit of its approximations. So far as the writer is aware, after a considerable inspection of the subject, absolutely every limit process which occurs in elementary mathematics is of this character, meaning by elementary mathematics, the mathematics of the secondary and primary schools. It is to be strongly urged that the simple notion of approximations, which is necessary in elementary mathematics in any event, be made the sole topic among these three equivalent topics of approximations, limits, and infinite series, in elementary school work, both because the idea is more quickly grasped, and because the other two topics have been presented fallaciously in our popular text-books, which has given rise to traditional misstatements which will be very difficult to eradicate.

As stated before, any constant is the limit of its approximations; but on the other hand, the converse is not true, for there are examples of limits which cannot be regarded as approximation processes; these exceptional forms do not occur in elementary work, however, and the very difficulties involved in their consideration would be eliminated from elementary instruction by confining ourselves exclusively to approximations.

The Abuses of Approximation Methods. One fundamental abuse of the approximation method is the failure to recognize that they are approximation methods. For example, in the ordinary process for square root, the writer is sure that the *impression* is often given that there exists a process for actually writing down a decimal which is the square root of 2, for example. What is really done, of course, is to write down successive decimals whose squares differ from 2 by less than any preassigned amount if the process is sufficiently extended.

Another very serious and fundamental error which is woefully prevalent, is the failure to realize that the quantity to be approximated must be defined. This failure is readily remedied, if it is once recognized. Thus it will be noticed that it has just been stated that a succession of decimals could be found whose squares approximate to 2; the writer was careful not to say that a set of decimals could be found which approximate $\sqrt{2}$. And this is very fundamental. For 2 is a perfectly defined number, and decimals whose squares approximate to it are readily comprehended; but is it clear in advance what the $\sqrt{2}$ is? Is it a defined number? Do we know that there is a number whose

square is precisely 2? Most assuredly we do not; in fact there is no integer whose square is 2, nor is the square of any fraction equal to 2, as will be seen upon inspection. What is this thing, then? Is it a number, yet not an integer, and not a fraction? Who ever heard of such a thing—at the time square root is first taken up? Indeed, then it is much simpler to say that decimals can be found whose squares approximate 2, than to say something about such a hazy concept as that jùst mentioned. It is this that the writer would urge—not that fine distinctions be introduced in teaching, but that statements be made in as simple and as correct a manner as we can.

There is no objection to using the phrase "the square root of 2" if this process has once been properly introduced. In fact the most careful definition of the "square root of 2" is to define it to be the number which is approximated by the decimals found in the process just described. Nor need this discussion be made abstruse in actual teaching. For, in order to be quite within the bounds of decent mathematics, all that need be said is, "In this process we find numbers whose squares come nearer and nearer to 2, so that the square of our result is as near to 2 as we please if the process be carried on long enough. We recognize the unending decimal produced by this process as a number, and call it the square root of 2." While this statement is possibly strange to you who are so familiar with what we have all been taught in our own elementary education, its strangeness to us is not an element of difficulty to the child who sees it for the first time; and it would not seem as hard to believe or comprehend as the essentially false statements which are more in vogue.

Areas as Approximations. As a notorious illustration of the abuses of approximation processes, let us consider the ordinary treatment of areas. A common definition of the area of a square, for example, is that "the area of any square is the number which expresses the number of times which the given square will contain a certain unit square chosen as the unit of area." The writer has no quarrel, just now, with the man who will say that the square to be measured contains the unit square two-thirds times, though two-thirds times is self-contradictory; —but this can easily be remedied by properly subdividing the unit square. But how shall a square whose side is irrational,—

say the $\sqrt[4]{2}$ or π,—be measured in terms of the unit square? For here no common measure exists. Even in case of the square whose side is $\sqrt{2}$ it is impossible to find a single measuring square which will really fit an integral number of times in the unit square and in the given one.

It is not hard to see what is really the case; certainly it would be easier to the student to tell him simply the truth about the matter, rather than have him puzzle over how he is going to fit squares into others into which they really do not fit. The truth is that we are face to face with another approximation process; and the writer sees no reason for disguising the fact. To be sure, it is impossible to find a square which will fit in the unit square and also in the square to be measured an integral number of times. But we can easily see that by choosing small enough squares which fit precisely in the unit square, we can fill the square to be measured as nearly as we please with the same little squares. Hence we can find a set of approximations which express the areas of squares which differ from the given one by as little as we please. The area of the given square is really the number approximated by these values.

It is seen that the notion of definition of the area is really involved in the last statement, and the area of the given square, which was left undefined by the original definition, is now quite a definite and defined thing. To the student we may simply say that we divide the unit square into hundredths, ten-thousandths, etc., by dividing the side into tenths, hundredths, etc., and we apply the smaller squares to the area to be measured. While these may not precisely fill that area they will do so more and more nearly, and the numbers obtained by counting these smaller squares intelligently are approximations to what we call the area of the figure which we desired to measure. This definition really defines, which is an advantage to be treasured. It applies as well to circles, triangles, etc., as to squares; and it prepares the student thoroughly for a reasonable understanding of area in all its phases.

Such a theorem as that two circles have areas which are proportional to the squares of their radii, really comes within the possibility of proof, if we proceed in this manner. It is a curious commentary that it is especially in those text-books in which the false assertion that all the theorems of plane geom-

etry are proved logically from the axioms is proclaimed most vociferously, that we find such fallacious proofs given the utmost prominence. Is it not evident that no theorem can possibly be proved about the areas of circles in a book in which no definition of area is given which in any sense applies to a circle? Nor is reference made to any special text. These fallacies have become traditional, so that many an author has inserted them without real forethought.

I will lastly call attention to the fact that all the theorems on similar triangles involve these same questions, and that these theorems cannot be proved unless the approximation in the very defininition of areas is recognized.

(*To be continued.*)

THE TEACHING OF GEOMETRY IN ITS RELATION TO THE PRESENT EDUCATIONAL TREND.*

By William Betz,

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Existence of a Reform Movement. A few months ago the principal of a well known school said to me, "The teaching of geometry has become stale. Something must be done to put new life into it." This remark struck the very keynote of the present reform movement. That one has a right to speak of a reform movement in the teaching of mathematics, must be evident to any but a very indifferent observer. The agitation in favor of better teaching is not confined to our own country, and its effects are felt in colleges, universities, secondary and primary schools, with almost equal force. It is unnecessary to recite before an audience like this all the details of its origin and progress. Many of those here present could do that more impressively. It is sufficient to say that since Prof. E. H. Moore's memorable address in December, 1902, "On the Foundations of Mathematics," an ever increasing number of teachers have become actively interested in the pedagogy of mathematics. This is shown to be true by the large number of associations of teachers of mathematics and science organized within the past five years and by the numerous papers and reports published in that time.

*Read before the mathematics round table, National Education Association, Cleveland, July 2, 1908.

A vigorous battle has been going on between the radical and conservative schools, between individualism and dogmatism. By this time the smoke of battle has cleared away sufficiently to warrant a diagnosis of the case and perhaps a prognosis.

It is my pleasant duty this afternoon to attempt a brief discussion of the geometry situation in our secondary schools in the light of present educational tendencies.

Transforming Influences. At the very outset it is proper to ask, is there any real need of a reform movement? Aside from the general reason of progress in every department of human thought and activity, some four or five additional factors are contributing to the state of affairs we are now considering.

1. In the first place, modern industrialism, with its demand for tangible success, has led to a great outcry for more practical school work. There is an increasing contempt of "mere theory." This feeling finds its expression in the establishment of trade and technical schools such as this beautiful city has the privilege of possessing. Geometry, as usually taught, furnishes a welcome target to the utilitarian educator. As a result there is a growing fear that we may drift too far from the ideal of liberal culture and that the direct bread-winning power of a subject may be made the sole criterion of its usefulness.

2. Our large cities, the natural centers of industry, are also becoming great centers of population. Naturally the struggle for existence is becoming keener. Many parents are now sending their children to the high school to fit them, in the briefest possible time, for a more comfortable life than they themselves enjoy. This has made the high school population more diversified than ever before and the demands imposed upon the schools have become more numerous from year to year. For the first time in history, secondary education is truly democratic. But it cannot be denied that the assimilation of so much raw material from homes giving no cultural impulses, and of so many students having no intention of entering higher institutions of learning, is one of the most serious problems of the high school.

3. More far reaching than these changes of ideal and environment have been certain revolutions in school curricula and methods of instruction. The natural sciences have risen from comparative obscurity into great prominence. Their inductive method of investigation is considered by many as the great panacea for all our troubles. The influence of the laboratory

method is undeniable. It is reacting, for example, on the teaching of history and the languages. In so far as it insists on self-reliance and definiteness of results and is productive of greater interest, it is excellent. But it lengthens school hours, calls for costly equipment, and demands much outside work on the part of pupil and teacher.

4. It would be difficult, moreover, to overestimate the effect of the "new education." Its fundamental precept that all work must be arranged psychologically and adapted strictly to the child's power of comprehension, is eminently sound. But it has also given us the enriched curriculum, and the doctrine of interest which replaces all objective standards by the subjective attitude of the child. Unquestionably this means at once a distinct advance and a very real source of danger. The complaint is not infrequent that in many cases the young are learning to depend too much upon the inspirational powers of the teacher, that all real difficulties are carefully avoided, and that the very aim of all true education, to develop a strong character and to create self-activity and initiative, is thereby defeated.

During the past five years we have heard much of the social function of the school. A prominent professor kindly informed us that until exercises in spelling, mental arithmetic and formal grammar should have become merely incidental and subsidiary, the high water mark in teaching would not have been reached. It is exaggerations of this sort that rob many otherwise excellent ideas of their legitimate influence and place upon them the stigma of the faddist.

5. Last, not least, I must refer to the molding power of recent research in the domain of pure mathematics. The labors of men like Pasch, Peano, Veronese, Hilbert, Klein, Russell, and others are making it clear that the subject of rigor in geometry is one of extreme delicacy. It appears that our text-books are full of hidden assumptions and that their usual boast of rigorous presentation is ludicrous.

Readjustments. Standing in the very midst of this whirlpool of conflicting forces and tendencies the conscientious teacher of mathematics feels vaguely, though instinctively, that his subject is in need of repair. His feeling is one of unenviable uncertainty. The new situation makes great demands on his training. He does not know how to steer clear of Scylla and Charybdis, how to modernize and revitalize his subject in the

face of the many obstacles that beset his way, not the least of which is represented by the inexorable requirements of examining boards. Is there any way out of the difficulty? As in all similar cases, a compromise would seem to be the natural outcome. Perhaps, by noting first the readjustments that have already taken place, we may secure a clearer vision of our future course. The old inflexible schedule of studies is giving way to a more liberal curriculum. This is a direct outgrowth of the doctrine of interest and of the new function of the high school as the people's university. Here also lies a great danger. Mathematics is one of the "hard" school subjects, and when it is placed in competition with easier and more attractive subjects, the pupil naturally follows the line of least resistance. As a college president happily phrased it, he abandons the Jerusalem of the calculus for the Jericho of economics. It has become a witticism that water does not flow down hill so smoothly as the delighted student picks his way through a long list of electives. In this connection the following passage, taken from the third report of the Association of Mathematical Teachers in New England (Boston, 1906), will be of interest: "That pupils and their parents are not awake to the importance of mathematics was shown conclusively by questions put to the principals of the Boston high schools in which the elective system is in force. In the English High and in the Roxbury High 25% of the entering class are taking no mathematics whatever. In the South Boston High 28% of the pupils have not made a year of algebra or geometry. In the Girls' High 53% of the first year pupils, in selecting their studies, chose no mathematics, 287 out of 544 girls; and in the East Boston High 165 out of 239 pupils in the entering class, or 69%, are studying no mathematics."

Of far greater interest and importance are the efforts that have been progressing for some time to modify the compartment system in the teaching of mathematics, by which algebra is placed in the first year and geometry in the second. While he is studying geometry, the student promptly forgets his algebra, and during the third year he loses both algebra and geometry. Then, in the fourth year, we try to revive his interest by going over the same ground a second time. There is a great waste of energy in all this. I cannot regard the introduction of "non-preparatory" courses as a complete solution of this difficulty, even if such courses were possible in all schools.

The various correlation and fusion plans advocated so far have not been tested sufficiently to warrant their general adoption. In 1902, Professor E. H. Moore designated the unification of pure and applied mathematics as the fundamental problem. Mr. John C. Packard, a year later, predicted the formation of a new subject known as "everyday mathematics," by the fusion of physics, manual training, algebra and geometry. This constitutes the very heart of the Perry Movement. The practical realization of this scheme proved more difficult than was anticipated. So far as I know, it has been tried only in schools of unusual equipment, and even there has been only moderately successful. One impartial observer, after a careful inspection of the schools where this sort of correlation seemed to work particularly well, reported that the good results were due, not to the plan as such, but to the consummate skill of the teachers, who in his opinion could have made almost any plan a success. Mr. F. T. Jones of University School, Cleveland, Ohio, expressed himself similarly a few weeks ago. The most significant utterance on this point is Professor G. W. Myers' report in The School Review, October, 1907, to which I can only refer. Although these experiments have not produced the results expected of them, they have by no means been useless. They have shown the teachers of mathematics their limitations, have awakened an interest in applied mathematics, and have greatly enriched our problem literature. More promising than these forms of external correlation have been certain more recent attempts to secure a closer union of the various branches of pure mathematics. These efforts are still confined to a few high schools and colleges. So far as it is safe to draw conclusions from a very limited experience, the indications are that here lies our only hope of overcoming the compartment system.

The Future Course. I trust that I have now established the necessity and the actuality of a reform movement in the teaching of mathematics. We must consider what will be the probable outcome of the struggle, as far as geometry is concerned. It is safe to say that whatever changes occur, they will all be in the direction of greater interest, more applied work, and fewer technicalities. It is also certain that the teacher of geometry must revise his aim, readjust the subject matter, and modernize his methods.

Aim. The one-sided theory of mental discipline in the elementary course must go. The over-insistence on discipline for its own sake has done incalculable harm to the interests of mathematics. It is well that we are beginning to realize this. The report of the New England Association mentioned above contains this lament: "The general impression is abroad that mathematics is of little practical value, and the result has been its neglect and the consequent loss of mathematical power on the part of the pupils." Ours is not the calm repose of the Greek philosopher. Our civilization craves action, and a subject that loses contact with life is doomed.

It is a mistake to suppose that the high school can distinguish sharply between rational geometry and intuitive geometry. Their separation at this stage of the pupil's development is neither possible nor desirable, as Professor John Dewey has pointed out. In fact, what is rational geometry? The content of this conception is far from absolute. Says Professor Moore, "The teacher is teaching the subject for the benefit of the students, and it must be admitted that beginners in the study of demonstrative geometry cannot appreciate the very delicate considerations involved in the thoroughly abstract science. Indeed, one may conjecture that, had it not been for the brilliant success of Euclid in his effort to organize into a formally deductive system the geometric treasures of his times, the advent of the reign of science in the modern sense might not have been so long deferred. Shall we then hold that in the schools the teaching of demonstrative geometry should be reformed in such a way as to take account of all the wonderful discoveries which have been made—many even recently—in the domain of abstract geometry? * * * To make reforms of this kind, would it not be to repeat more gloriously the error of those followers of Euclid who fixed his 'Elements' as a text-book for elementary instruction in geometry over two thousand years ago?" Let us be perfectly honest about this matter. Let us give up that meaningless pretense of teaching rigorous geometry to boys and girls of fourteen or fifteen.

Subject Matter. Is it not true that we are trying to crowd into a single year more material than the young student can possibly absorb? Think of the many definitions, the 160 propositions, the numerous corollaries and originals called for by the usual course. We can secure a mechanical repetition of these

things, but do they become part of the pupil's mental armature? Should we not eliminate all that is not absolutely essential?

I know of no better criterion for this process than Prof. Klein's definition of elementary mathematics: "In all domains of mathematics those parts are to be called elementary which can be understood by a pupil of average ability without long continued special study."

In the light of this eminently sensible definition, advanced by one of the greatest of living mathematicians, we can afford to omit those things which experience has proved to be of little or no value. There is a growing conviction that to this class of material belongs the whole subject of limits and incommensurables. Many secondary teachers, both here and abroad, have long been of this opinion. For information on this point, I may refer to the reports of the New York High School Teachers' Association, of the New England Association, and the Central Association. It is a great pleasure to note that even the colleges are adopting this view. In a paper published in SCHOOL SCIENCE AND MATHEMATICS, Prof. H. E. Hawkes of Yale University says: "During ten years' experience in teaching geometry to students who have been in general carefully prepared by the best teachers, I do not believe I have met a dozen who understood the theory of limits. This is not the fault of the students nor of the teachers, nor entirely of the text-books. The difficulty lies in the fact that we are trying to do something that cannot be done. * * * From every point of view that I am able to take, the theory of limits in elementary teaching seems a failure. If both secondary and college teachers suddenly discover that they agree on this point, the rest is simple." Professor G. A. Miller writes: "It has become the fashion of text-book writers to call especial attention to the rigor of their presentations. Fortunately these claims are generally unsubstantiated. There are few things that would give more definite proof of the perfect unsuitableness of an elementary text-book than the fact that every step in the presentation was rigorous."

Applications. The time gained by such omissions could be devoted to the more significant topics, and would enable us to introduce at least a few interesting and valuable applications. The young student should not be expected merely to review formulas and recite theorems discovered ages ago. He has a perfect right to ask what it is all for. Fortunately, the geom-

etry teacher, if he will take the necessary pains, need not fear this inquiry. The desideratum seems to be such a judicious mixture of theory and practice that complete oblivion will settle on the definition according to which "mathematics is the science in which we do not know what we are talking about and do not care whether what we say about it is true."

A National Syllabus. Now I grant that the elimination of non-essentials is a serious matter, if left entirely to the judgment of the individual teacher. Each teacher is more or less of a hobbyist. I therefore suggest that the various provisional syllabi now at our disposal be submitted to a new committee of ten which shall work out a national geometry syllabus. If compiled with the greatest care by representative men, men in close touch with the colleges and the secondary schools, it should exert the same unifying influence that has characterized the publications of former committees of the National Education Association. This national syllabus should be revised periodically, possibly every ten years. It should contain a carefully graded list of theorems. It should also give a discussion of disputed definitions, terms and symbols, and should offer advice as to methods of procedure.

Methods. This brings me to my last topic. More seems to have been written in the past five years on the pedagogy of mathematics, than during the preceding five decades. This is very reassuring. When many prominent mathematicians can devote so much of their energy to the interests of elementary mathematics, better times are surely coming. It is encouraging that we are gradually seeking emancipation from text-books, that the teacher really teaches. The genetic method and the laboratory mode are receiving their due amount of attention. There is an attempt to make the pupil a discoverer, to replace the receptive attitude by a creative spirit. We are securing a better balance between oral and written recitation. Text-books, too, are improving in arrangement and quality of material. In short, there is progress all along the line.

Conclusion. In conclusion I would say that the present situation more than ever before demands a real teacher, a teacher of broad scientific and pedagogic attainments, who, in spite of many unavoidable disappointments, knows how to preserve his optimism. Never in the history of the world have the opportunities for sound training been greater, never has the unique

importance of mathematics been more generally recognized, nor has there been more mutual sympathy and coöperation. Many years ago an ardent admirer of our noble science, a romantic poet now almost forgotten, wrote these admonishing and inspiring words: "The true mathematician is an enthusiast, *per se*. Without enthusiasm, no mathematics. The life of the gods is mathematics. All divine messengers must be mathematicians."

ROCK CITY.

By William B. Kinnear,

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In Ottawa County, Kansas, three miles southwest from Minneapolis, the county seat, there is an interesting phenomenon popularly known in the vicinity as "Rock City." The "city" consists of numerous rocks, mostly spherical in form, varying in size from twelve feet in diameter down to three feet. There are two groups, one embracing most of the larger and more perfectly spherical specimens, the other including, for the most part, smaller rocks with greater departures from prevailing type. The latter group is a few yards east of the other and the rocks are less numerous as well as smaller. The rocks are situated about halfway up the slope to the upland west of the Solomon

Valley. The country west of the valley is hilly, east of the river mostly level prairie with portions gently undulating.

Old settlers say that the rocks have changed from a distinctly whitish appearance in early days to their present weather-beaten gray. Some of the nodules in the larger group rest on bases of softer stone, while others have toppled over as their bases decayed and crumbled.

In the fields to the west are scattered fragments of similar rocks in various stages of disintegration, and down the valley to the east are others of the same order but smaller, less numerous, and of less pronounced spherical form.

PRELIMINARY REPORT OF THE COMMITTEE OF THE MATHEMATICS SECTION OF THE CENTRAL ASSOCIATION ON THE UNIFYING OF SECONDARY MATHEMATICS.

The discussions of the past decade have made it plain that the question for consideration is not concerning the propriety of a closer union of the subjects in secondary mathematics, but rather concerning ways and means for a speedy realization of the benefits which are certain to follow such a union.

Very few secondary schools can enter at once upon an ideal course in mathematics, but all schools can take some steps toward an improvement of present conditions. Teachers in the smaller schools where it is frequently necessary to combine such departments as mathematics and physics, or to have all the mathematics taught by one teacher, have unusual opportunities for testing the plans proposed by the committee, and can do much toward a practical solution of the problems of correlation. The movement will be hastened and the ideals realized at a rate directly proportioned to the intelligent interest and activity displayed by all teachers of mathematics. Mathematics makes perhaps a greater demand upon the teacher's personality than any other subject of the curriculum. It is the teacher's privilege and duty to determine in large part the student's attitude toward this whole range of intellectual activity. It has been well said that he must be "an idealist, an optimist, an enthusiast, and a specialist."

All teachers of mathematics desire to keep themselves informed upon recent advances in the teaching of the subject, by reading and filing for reference the reports which are frequently appearing in various publications. To assist in this there is appended to this report a bibliography of material which has been found of special interest and helpfulness to teachers who have been experimenting with new methods. The files of the official organ of this association, SCHOOL SCIENCE AND MATHEMATICS, contain much in the way of articles which record the results of actual trial of the plans under discussion.

We urge upon teachers the desirability of embracing every opportunity for introducing into our teaching any phase of mathematics which will throw light upon the topics under consideration. Instead of being tied down by tradition and custom

to a set order of topics and to a cut and dried treatment of the same, let us feel at liberty to assert our individuality and employ whatever means will best meet the present need. If we know arithmetic, algebra, geometry, and trigonometry in their relations to one another, there will be no hesitation about introducing material from one subject into the teaching of another whenever such material is needed. Professor Perry in his "Discussion on the Teaching of Mathematics" says that we may present in geometry, "Measurement of angles in degrees and radians. The definitions of the sine, cosine, and tangent of an angle; determination of their values by graphical methods; setting out of angles by means of a protractor when they are given in degrees or radians, also when the value of the sine, cosine, or tangent is given. Use of the tables of sines, cosines, and tangents. The solution of a right-angled triangle by calculation, and by drawing to scale. The construction of any triangle from given data; determination of the area of any triangle."

Squared paper is within the reach of every teacher and the uses to which it can be put are numerous and valuable. One of the imperative duties of the algebra teacher is to make the use of squared paper as familiar and as natural to his students as the use of any other of the familiar appliances of his study. The geometry of Godfrey and Siddons shows how readily geometric problems may be solved by it. The student makes of his own accord a plan to illustrate his study of some historical movement, and should just as naturally illuminate his study of an equation or of a problem. His inspiration to this must come from a living teacher. The time for the introduction of the scheme is when its need first appears, whether that is in the sixth grade or in the ninth. The fundamental ideas are easily presented and connected with what is already known of latitude and longitude, and of township plotting. Material for further training is abundant. It is in the daily papers and the yearly almanacs, and also in the community life. Weather statistics, crop reports, variations in population, economic conditions, all afford a rich field for plotting material. Some of the recent texts on algebra abound in suggestions for graphic work and in practical applications in problems and in the representation of functions. No teacher need hesitate for lack of material and of efficient instruction in its use.

Graphic illustration stimulates thought, requires close obser-

vation and reasoning, and tends toward accuracy. It is invaluable in physics, political science, and other studies of the curriculum. It gives the equipment for later interesting and delightful study of the forms of higher mathematics. For these reasons it is deserving of the prominent place accorded it in the discussions of the past few years, and it is worth the careful consideration of all teachers.

The lists of problems found in the texts in secondary mathematics which are generally used throughout the schools, are in much need of revision and supplementing. There is a wide field here for the activities of all teachers of mathematics. The traditional lists are composed of problems based on number relations; of problems which have an historical interest, such as courier and cistern problems; of those which represent fanciful conditions; or, and this has always been the smallest group, of those which set forth real and practical situations in the world of affairs. Within very recent years much attention has been given to the enlargement of this latter group and with excellent results as shown in recent text-books. We all may assist here either by testing lists of problems already compiled or by making lists of our own. In making these lists we should secure the active coöperation of our students and should make the lists represent local needs and local conditions as far as possible.

Such lists of problems furnish a rather easy and safe method of attempting to unite the subjects of secondary mathematics. In first year algebra problems in percentage, interest, proportion, mensuration, and so on, may be used to connect the algebra with the arithmetic, and to prepare the way for geometry. This is well done in some of the new text-books, and much excellent work in concrete geometry may be done while the pupil is solving algebraic problems dealing with triangles, circles, regular polygons, and so on. Dr. Myers' "Geometric Exercises for Algebraic Solution" is a revelation of the direct and simple way in which the year devoted to geometry may be made of vastly more value to the average pupil. If it is possible for a teacher to omit many theorems which are not really necessary, to give only a little time to limits, then he can use the algebraic problems so as to give the pupils a stronger grasp of algebra and a better working knowledge of geometry. Moreover, the proofs of many theorems can be thrown into algebraic form by using a single small letter to denote a line, angle, or triangle, and the

tendency to memorize proofs be avoided. The laws of physics so far as they come within the comprehension of the pupils may be used as the basis for algebraic exercises. While the teacher of mathematics cannot take time to teach the subject of physics, the laws of density, specific gravity, levers and so on, are so much a matter of common experience, that they can easily be discussed and used in the classes in mathematics. Here again we have valuable and easily accessible material in recent text-books.

It cannot be too strongly emphasized that correlation should in general be attempted by lists of problems, rather than by a change in program to teach algebra and geometry simultaneously or alternately, using our present text-books. However, the following curriculum will show how masterly the problem has been worked out in Prussia, and may aid us in experimenting.

The Mathematics Curriculum of the Hohenzollern Oberrealschule, Schöneberg bei Berlin, from the Annual Report, 1906.

FIRST YEAR.

Arithmetic. Günther-Böhm, sections 1-39. 1st quarter: The number system. Reading and writing numbers. The four fundamental operations with abstract numbers. Simple proportion (section 6). Simple problems combining the four fundamental operations, with integers and the use of parentheses. 2nd quarter: The decimal system of money, mass and weight; changing and reducing. Exercises in proportion. 3rd quarter: The general number system (sections 12 and 13). Addition and subtraction of concrete and abstract numbers. Multiplication and division of the same by integers. 4th quarter: Further problems on counting and measure of time. Changing and reducing and use of the four operations. Applied problems from sections 23 and 27. Combination of the different methods of calculation with abstract numbers and the use of parentheses. Simple problems in chronology.

SECOND YEAR.

Arithmetic and work in preparation for geometry. (a) Arith-

metic, Günther-Böhn, sections 40-53. 1st quarter: Definition and evaluation of fractions; proper and improper fractions; changing whole and mixed numbers to improper fractions and the inverse. Factoring and the divisibility of numbers; notion of powers. The G. C. D. of two numbers. Reduction of fractions. 2nd quarter: Multiplication and division of fractions; their use in simple proportion. 3rd quarter: The L. C. M. of several numbers; common denominator. Addition and subtraction of fractions. 4th quarter: Review of the different kinds of computation with decimal fractions, multiplication and division of decimal fractions. Review of the work of the first two years. (b) Work in preparation for geometry.

Third Year.

Arithmetic and geometry. (a) Arithmetic, three hours a week, changing common fractions to decimal fractions and the inverse (Günther-Böhm, sections 54 and 55). Short methods of computing with decimal fractions (section 56). Compound proportion and interest (57-60). Algebraic numbers; notion of them, computing with them while reviewing the work of the first two years. (b) Geometry, three hours a week. Theory of lines, angles, triangles, and quadrilaterals. Simple construction problems.

Fourth Year.

Mathematics. 1st quarter: Addition and subtraction of literal numbers in connection with equations of the first degree; (b) Review of the parallelogram. Theory of the circle, part I Mehler, in connection with sections 48-56. 2nd quarter: (a) Multiplication of literal numbers, equations of the first degree; (b) Theory of the circle, part II Mehler, in connection with sections 57-61. 3rd quarter: Multiplication of algebraic expressions. Division of literal numbers, equations of the first degree, proportion; (b) Theorems in regard to areas and the computation of the area of rectilinear figures, in connection with sections 62-64, 71 1 and 2, 72. 4th quarter: (a) Division of algebraic expressions, equations of the first degree. (b) Notion of projection. The Pythagorean proposition in connection with sections 65-70 and 72, remark. In all four quarters problems

in geometric constructions with and without analysis (r, ρ, sum and difference of parts and areas). In the sixth lesson of each week, problems in geometric construction during the summer semester, and in the winter semester problems from daily life and the so-called mercantile calculation.

Fifth Year.

Mathematics. One hour a day will be given to the continuation of construction problems and problems of everyday life. Summer semester: (a) Powers with positive and negative exponents. Roots. Linear equations with one unknown. (b) Theory of similarity (Mehler, sections 73-94). Winter semester: (a) Roots (continued), powers with fractional exponents. Linear equations with one and several unknowns. Quadratic equations. Introduction to imaginary quantities. (b) Regular polygons. Calculations on the circle. Algebraic geometry (Mehler, sections 95-107 and 120, 121).

Sixth Year.

Mathematics. Review of geometry in the winter, and of algebra in the summer semester. Summer: (a) Introduction to logarithms. Laws of logarithms. Calculation with logarithms. (b) Trigonometry: Fundamentals of goniometry. Computations with right-angled and isosceles triangles. Applications of algebra to geometry. Construction problems with algebraic analysis. Stereometry: Introduction to perspective drawing. Calculating the length of the edges, surface, and volume of simple solids. (b) Quadratic equations. (Oral problems). (c) Review problems from all domains, especially problems which have to do with practical life and the mechanic arts.

Seventh Year.

Mathematics. Summer: (a) Theory of harmonic points and rays, chords, centers and axes of symmetry; construction of algebraic expressions. (b) Complex numbers. Binomial equations. Difficult quadratic equations. Winter: (a) Goniometry (including the addition theorem) with difficult computation of triangles. The systematic laying of the foundation of stere-

ometry and the systematic building up the subject. (b) Quadratic equations with several unknowns. Arithmetic and geometric series. Calculation of interest and annuities.

EIGHTH YEAR.

Mathematics. Summer: Conic sections, elementary synthetic treatment. Combinations, with applications in the theory of probabilities. Cubic equations. Winter: Spherical trigonometry with application in surveying and astronomy. Binomial theorem for any exponent. The most important series of algebraic analysis. In both semesters in an hour for review, exercises which shall bring together and extend the work in all domains of the preceding classes.

NINTH YEAR.

Mathematics. Analytic and descriptive geometry. Theory of equations. Biquadratic and Diophantine equations. An elementary study of the differential and integral calculus. A constructive review of the algebraic work during the course.

Text-books, Rechenbuch für höhere Lehranstalten (mit Anhang). Günther und Böhm, M. 2.20. Mathematische Hauptsätze, Ausgabe für Realgymnasien und Oberrealschulen, Bork-Nath, Teil I M. 2.50, Teil II M. 3.60. Aufgabensammlung, Neue Ausgabe, Bardey, M. 3.20. Hauptsätze der Elementar-Mathematik, Mehler.

The interest in the whole question of improving the teaching of mathematics is evidenced by the great number of books on various aspects of the subject which have appeared in America, England, Germany, France, and Italy during the past few years. A very brief list of the books which contain live problems and methods, and which will aid teachers in correlating secondary mathematics is here given:

Teaching of Mathematics. Perry. pp. 123. 1902. The Macmillan Co. 70 cents. Address before the British Association by Professor Perry, and discussion. A plea for concrete, useful mathematics. Beginning of the Perry movement.

The Teaching of Mathematics. Young. pp. 346. 1907. Longmans, Green & Co. $1.50. Packed full of helpful suggestions, lists of books.

The Teaching of Mathematics in Prussia. Young. pp. 141. 1900. Longmans. 80 cents. General account of the higher school system and more detailed description of the work in mathematics.

Workshop Mathematics. Castle. pp. 331. 1900. Macmillan. 65 cents. Part I, simple arithmetical and algebraic methods, areas and lengths. Part II, logarithms, slide rule, areas, irregular figures, volumes.

Practical Mathematics. Perry. pp. 183. 1907. Wyman, London. Paper covered. 20 cents. Not many problems, advanced, many good hints and suggestions.

Preliminary Practical Mathematics. Starling and Clarke. pp. 168. 1904. Arnold. 40 cents. Elementary; arithmetic, algebra, good problems.

Practical Mathematics. Consterdine and Barnes. pp. 332. 1907. John Murray. 65 cents. "For use of students over twelve years of age." Arithmetic, algebra, geometry.

Practical Mathematics. Stern and Topham. pp. 376. 1905. Bell. 65 cents. Graphs, good physics problems; advanced.

Junior Practical Mathematics. Stainer. pp. 360. 1906. Geo. Bell and Sons. 90 cents. Arithmetic, algebra, geometry, mensuration, graphs; elementary; good.

A Manual of Practical Mathematics. Castle. pp. 548. 1904. Macmillan. $1.50. 250 pages good problems and methods, algebra, geometry, trigonometry, squared paper; rest advanced. algebra, calculus.

Elementary Practical Mathematics. Castle. pp. 412. 1899. Macmillan. 80 cents. More elementary than the Manual.

Practical Mathematics. Cracknell. pp. 378. 1906. Longmans, Green & Co. $1.50. Arithmetic, algebra, mensuration, graphs, trigonometry.

Practical Mathematics. Saxelby. pp. 438. 1905. Longmans, Green & Co. $1.50. Good problems, logarithms, trigonometry, use of formulas, graphs, calculus.

Easy Mathematics, Chiefly Arithmetic. Lodge. pp. 436. 1906. Macmillan. $1.15. Few problems. "One continuous hint to teachers—to assist them in methods of presentation."

First-Year Mathematics. Myers. pp. 181. 1907. The University of Chicago Press. $1.00. Mixed mathematics, emphasis on algebra; geometric representation of quantity, good concrete, practical problems.

Elementary Geometry. Godfrey and Siddons. pp. 350. 1903. Cambridge University Press. 87 cents. A practical geometry; 1,829 exercises and problems, many of them concrete and practical.

A Manual of Geometry. Eggar. pp. 325. 1906. Macmillan. 87 cents. Practical and numerical problems, constructions.

Mensuration. Edwards. pp. 304. 1902. Arnold. 90 cents. Logarithms, trigonometry, good problems.

Elementary Mensuration. Chivers. pp. 344. 1904. Longmans, Green & Co. $1.25. Good problems, plane rectilinear figures, the circle, conic sections, solids, specific gravity, miscellaneous formulæ.

Geometrical Exercises for Algebraic Solution. Myers. pp. 71. 1907. The University of Chicago Press. 75 cents. 800 or more exercises based on geometry to cover algebra through quadratics.

Computations. Langley. pp. 184. 1895. Longmans, Green & Co. $1.00. Short methods of arithmetical computations, a few good problems.

Studies in Graphic Arithmetic. Lightfoot. pp. 63. 2nd edition. Normal Correspondence College Press, London. 40 cents. Many problems solved by graphs.

Treatise on Graphs. Gibson. pp. 181. 1905. Macmillan. $1.00. Many good problems and methods.

Graphic Algebra. Phillips and Beebe. pp. 156. 1904. H. Holt & Co. $1.60. Plotting and properties of curves, solution of equations.

Plane Trigonometry. Bohannan. pp. 374. 1904. Allyn and Bacon. $2.50. Approximate number, computation, good problems.

Practical Trigonometry. Playne and Fawdry. pp. 176. 1907. Arnold. 65 cents. Good problems, applications of algebra and geometry.

Measurement and Weighing. Edser. pp. 120. 1899. Chapman and Hall, London. 65 cents. Experiments in measuring lengths and angles, computing heights, areas, volumes, trigonometric ratios, mass, and density. Simple, clear, good.

Mechanical Engineers' Pocket Book. Kent. pp. 1129. 1906. John Wiley & Sons. $5.00. A storehouse of data for problems.

A Note Book of Experimental Mathematics. Godfrey and Bell. pp. 64. 1905. Arnold. 50 cents. "Contains directions

for such experiments in physical measurements, hydrostatics, and mechanics as seem best fitted to accompany and illustrate a course of mathematics."

1,000 Problems in Physics. Snyder and Palmer. pp. 142. 1902. Ginn and Co. 55 cents. Many simple problems for mathematics.

Mechanics Problems. Sanborn. pp. 194. 1906. John Wiley and Sons. $1.50. Easy and more difficult problems.

Elementary Algebra. Comstock. C. E. Comstock, Peoria, Ill.

Practical Elementary Algebra. Collins. The American Book Co.

Algebra for Secondary Schools. Hedrick. The American Book Co.

High School Algebra. Elementary Course. Slaught and Lennes. Allyn and Bacon.

High School Algebra. Advanced Course. Slaught and Lennes. Allyn and Bacon.

First Course in Algebra. Wells. D. C. Heath and Co.

Elementary Algebra. Young and Jackson. D. Appleton and Co.

(An outline for a four year course in secondary mathematics is in preparation, and will be published as a part of this report in the December number of SCHOOL SCIENCE AND MATHEMATICS.)

It is particularly desirable that records be kept of the results gained by following out the recommendations of this report, and that advantage be taken of every opportunity for giving publicity to these records through educational meetings and educational journals. All teachers can thus have a part in some phase of this forward movement, and can very materially assist in formulating a practical working course in secondary mathematics.

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THE RELATION OF THE TECHNICAL WORLD TO SCHOOL CHEMISTRY.*

By William Conger Morgan,

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A glance at the history of education during the last decade or so may be of advantage at the beginning of the present consideration to show us the position from which we have progressed and the direction of present day tendencies.

Twenty years or more ago the university and the common school found themselves in diametrically opposite positions. The college course of that time consisted almost entirely of mathematics and the classics, subjects intended to give to the student a liberal education and to impart to him as much culture as possible during his four years' sojourn in the college walls. The education furnished by the common school was almost entirely practical, "the three R's—readin' 'ritin' and 'rithmetic"—being those subjects of which the average man makes almost continual use. The high school course, occupying an intermediate position, partook of the character of both, inclining rather to the side of the practical than the cultural.

To-day the positions of the university and the common school have become to a considerable extent interchanged. By the introduction of what has been termed "the fads and frills courses" into the grammar school the attempt has been made to stimulate the development of the younger students in the lines of culture and æsthetics while the development of schools of law, medicine, agriculture, and engineering of all kinds have tended to make the university course for many of its students a training for future life work to the entire exclusion of all cultural ideas. The high school of to-day, again following both leads, offers so many courses of such diverse character as to make classification difficult.

The fact that the university has found it necessary to modify its curriculum in order that it may meet the practical needs of its students, while the common school has found it advantageous to emphasize to a somewhat greater degree those things for which the college formerly stood, are significant facts, however, and seem to indicate that neither the practical man nor he that is cultured merely is to be considered as the ideal product of our

*Address, illustrated with experiments, delivered at the meeting of the Pacific Coast Association of Chemistry and Physics Teachers.

educational system. The call of the world to-day is for men who can *do*—who can clearly see the need of any situation in which they may be put and, seeing, can successfully accomplish those things that are necessary. The aim of education should be to develop thinking, feeling, and willing beings—men who "wear out but do not rust out." Along the line of the thinking being, the demand is for men of keen and accurate observation and sharp and logical reasoning, possessing the ability to use the knowledge gained in school, college, and later life to plan and work independently. The schooling period of such a man is to be regarded not so much as a collecting trip for the accumulation of facts as an apprenticeship during which the youth becomes acquainted with methods and knowledge to be used as tools in the everyday work of later life.

Important as is the development of the feeling and willing sides of man's nature, these points are not within the scope of the present treatment and will not be considered further.

After these considerations we may ask ourselves to what end shall industrial applications be introduced into a high school course in chemistry.

I shall answer first of all that it should never be with the idea of making the course practical in order that the student who shall not continue his education further may go out into the world and apply himself to the task of the metallurgist, the pigment maker, or the soap manufacturer. This end could never be accomplished in the high school course of the present day, and even were it possible, it is certainly far better for the student whose education ceases with the high school to be taught to see clearly and accurately what is happening about him and to reason logically from his observations to the results to be expected therefrom according to the principles of chemistry, physics, or any other of the natural sciences.

On the other hand the science of chemistry is so closely connected with modern industrial progress that it is well to impress upon the mind of the young student how splendidly certain of the thinking men have been able to apply the knowledge of method and of fact gained during school hours to the solution of practical problems and how glorious and far-reaching are the results of so doing. Illustrations of this character cannot fail to excite interest, and certainly the awakening of interest and enthusiasm is a legitimate reason for their introduction.

The speaker would maintain, however, that possibly the best reason for introducing experiments from the industrial world is to illustrate the general principles of chemistry. If these principles, usually developed from a consideration of reactions performed in a test-tube or small beaker, can be shown to control those processes upon which we are dependent for the comforts and necessities of life, they will not lose interest or significance thereby.

The experiments should be introduced in such a way as to suggest the industrial process, but not with the idea of duplicating or repeating it. The reactions which take place when the reagents are measured in tons instead of in fractions of a gram usually depend for their success on attention to minute details as to temperature, dilution, and proportion of reagents and it is often quite impossible to duplicate them on a small scale.

One general class of illustrations from the technical world may be suggested as particularly valuable and well adapted for introduction into a high school course in chemistry. It is the production of well known substances from naturally-occurring material and the utilization of the products so obtained in subsequent experiments. From work of this character practice in extraction, filtration, crystallization and other methods of manipulation is obtained. The idea of a continuity in his work and of the dependence of one experiment on another appeals to a good student and emphasizes the necessity that an experiment must be made to "come out right" or be repeated in order to obtain the material for subsequent work.

The production of beautiful white crystals of alum from a shovel full of ordinary dirt is a very suggestive experiment to the average student. The chief source of aluminum compounds becomes firmly fixed in his mind and the typical reactions of the metal learned from a study of a product of his own making are considerably more interesting than when the material is obtained from the reagent shelf.

The extraction of "pearl ash" from wood ashes and the preparation from it of "potash lye" or of saleratus or soap is another series of experiments of the same kind.

The analogous manufacture of "soda" from salt according to the methods of the Le Blanc or Solvay processes at once suggests itself. The action of "washing soda" in "softening" water

may be emphasized by treating its solution with dilute solutions of calcium and magnesium salts and the use of "baking soda" in leavening breadstuffs may be fixed on the mind by the actual manufacture of samples of "baking powder," the virtues of which may be demonstrated by use in the home.

To Californians, also the preparation of borax or boric acid from colemanite or ulexite will occur to mind.

The industrial world presents so many different aspects that the choice of material becomes a question of some difficulty because of the superabundance offered for selection. The most commonplace processes are those about which we should know first of all. They will be found in general most interesting and the introduction of such of them as are practical under the conditions existing in any given laboratory should first be essayed.

The "burning of limestone," slacking of lime, making and "setting" of mortar may all be performed in the laboratory without difficulty. Similarly the "burning" of gypsum to make "plaster of Paris" and the heating together of limestone and clay for the manufacture of Portland cement will furnish products with which the phenomenon of "setting" may be easily observed.

All the reactions of photography from the making of the plate and the printing paper to the "toning" of the print may be repeated in the laboratory. The chemistry of the main reactions may be explained on the basis of simple general principles and the processes prove exceedingly fascinating.

Many of the metallurgical processes may be illustrated. Mercury is readily obtainable from cinnabar, and lead from galena by simple experiments arranged along the lines of the metallurgy of these metals given in every text-book. Finely powdered chalcocite or chalcopyrite "weathers" readily in a moist atmosphere and from the resulting sulfate solution electrolytic copper is readily deposited. In regions particularly interested in mining the amalgamation, chlorination or cyanide processes for the extraction of gold may be easily illustrated by treating small amounts of "concentrate" according to the well known methods.

Sulfur dioxide obtained by the "roasting" of pyrites or the sulfids of other metals may be converted into sulfuric acid without difficulty. Platinized asbestos (made by soaking asbestos fibre in platinum chloride and then igniting it) serves to catalyze the mixture of sulfur dioxide and air and leads to the formation of dense white clouds of sulfuric anhydride, thus illustrating

the newer "contact process." By bringing together in a large flask sulfur dioxide, air, steam and nitrogen dioxide, the reactions of the "chamber process" may be suggested. A little skill in glass blowing will be sufficient to produce a working model which will show the pyrite burner, Glover and Gay-Lussac towers as well as the main chamber in which the reaction takes place.

The distillation of Chile saltpeter or crude calcium acetate with sulfuric acid shows the industrial methods for the production of nitric and acetic acids respectively. In the latter case, if it be thought desirable, the production of the calcium acetate may be suggested by the distillation of a retort full of sawdust and by passing the vapors over lime which is maintained at a temperature above that of boiling water. The large amounts of water and combustible gas liberated in this process should be emphasized by the condensation of the former and the combustion of the latter.

These experiments call to mind the distillation of coal with the production of coke, coal gas, ammonia, and coal-tar. The derivation of the perfumes, flavoring extracts, aniline dyes and drugs from this last material should not fail to be set forth. By passing steam over red-hot coke the manufacture of "water-gas" may be shown.

Among other high-temperature reactions may be mentioned the making of glass by fusing sand and limestone together with a salt of lead, sodium or potassium and the product may be variously colored by the addition of iron, cobalt, manganese, chromium and the like. In connection with "water-glass" the fireproofing of wood and the preserving of eggs may be tried.

If the electric current be available, calcium carbide may be made in small amounts by forming an arc between carbon electrodes inside of an ordinary sand crucible into which a mixture of charcoal and lime is thrown in small amounts from time to time after the establishment of the arc.

Several very beautiful experiments along the line of pyrotechnics may be arranged by mixing sugar and an oxidizing agent together with some substance to give color to the flame. The alkaline chlorates combine the last two functions, furnishing the oxygen and the color at the same time. Strontium chlorate and sugar is a mixture largely used in commercial "red-fire." Barium chlorate produces the green flame, potassium the lavender, and calcium the orange. The blue flame is more difficult to

obtain, and requires the previous preparation of ammonia-copper chloride by precipitation by means of alcohol of a strong solution of copper chloride previously treated with ammonium hydroxide in excess.

The fact that various substances with which the student becomes familiar in a general course in chemistry find technical application as pigments under the trade names of "white lead," "zinc white," "chrome yellow," "chrome orange," "cadmium yellow," "vermillion," "Indian red," "Prussian blue," etc., may help to maintain interest during the course.

As an illustration of the laws governing the formation of salts and the precipitation of insoluble substances from solution the methods in vogue in the dyeing establishments are worthy of note. Most organic dyes are either acid or basic in character and hence affix themselves to animal fabrics by forming insoluble salts with silk or wool which possess the properties of uniting with both acid and base. Vegetable fibre, on the other hand, seems to be a neutral body possessing neither acid nor basic properties. It does not form insoluble compounds with organic dyes generally and therefore the color may be readily removed from the fabric by washing. By the use of "mordants," however, the colors may be permanently fixed. A "mordant" is any substance which will form an insoluble colored compound with the dye. The hydroxides of the heavy metals serve as "mordants" for acid dyes while tannic and other weak acids act in the same capacity for dyes which are basic in character.

These insoluble precipitates are very generally used as water-color pigments under the name of "lakes," the aluminum salt of carminic acid (the essential principle of cochineal) being known as carmine lake and the aluminum salt of alizarin (the dye obtained from the madder plant) as madder lake.

If the vegetable fibre be thoroughly impregnated with the reagents necessary to produce these compounds the lake will be precipitated throughout the entire fabric and will give a color to the goods which, since the lake is insoluble, cannot be removed by washing. In this way cotton goods are dyed fast colors, the well-known "Turkey-red" being simply madder lake deposited in finely-divided condition throughout the entire fabric.

These processes may be readily illustrated by adding salts of aluminum, chromium, iron, lead and tin to boiling solutions of the dyes. If the "lake" is not precipitated immediately, the

addition of a few drops of ammonium carbonate will bring it down.

By saturating cotton goods with a boiling solution of the salts and the dye and dipping for a moment or two in a hot ammonium carbonate solution, the color may be affixed to the fabric.

Since the different metals produce different colors with the same dye, if cotton be stamped with pastes consisting of gum-arabic mixed with salts of the various metals, different colors may be produced by once dipping into the dyeing solution, thus illustrating the method of the "calico printer." By treating cotton with four different pastes containing respectively aluminum, ferric iron, chromium and tin salts four different colors, red, black, lavender and brown, may be produced by one immersion in boiling water to which alizarin and ammonium carbonate have been added. These experiments are not at all difficult to perform and they appeal strongly because of their novelty.

Following a somewhat different line, the process of fermentation by which sugar or starch is changed into carbon dioxide and alcohol and this latter oxidized to acetic acid or vinegar are worthy of consideration. Attention might be directed also to those experiments which demonstrate the necessity of proper nourishment for plants. Comparative experiments on the growth of seedlings planted in pure quartz sand and fed with solutions of nitrates, phosphates, potash, and lime, on the one hand, when these are all present in the proper proportions, and on the other when certain ones are lacking will teach the value of fertilizers and of rational soil treatment.

In conclusion a word in regard to cooking and allied processes may not be out of place. There seems to be a strong desire on the part of some people to see this subject introduced into the high school course in chemistry, because of the belief that it would be particularly valuable and helpful. It is well to remember that the chemist would have difficulty in differentiating by chemical methods alone between a raw and a cooked potato, or between a live steer and a deliciously broiled porterhouse. What the effect of cooking is can hardly be expressed in chemical terms other than that the change consists mainly in the loss of more or less water. The physical changes are so much more evident that it would seem that such a topic might be introduced with much greater propriety into the course of physics.

CHEMICAL PLANTS.

By Raymond F. Holden,

Central High School, Kalamazoo, Mich.

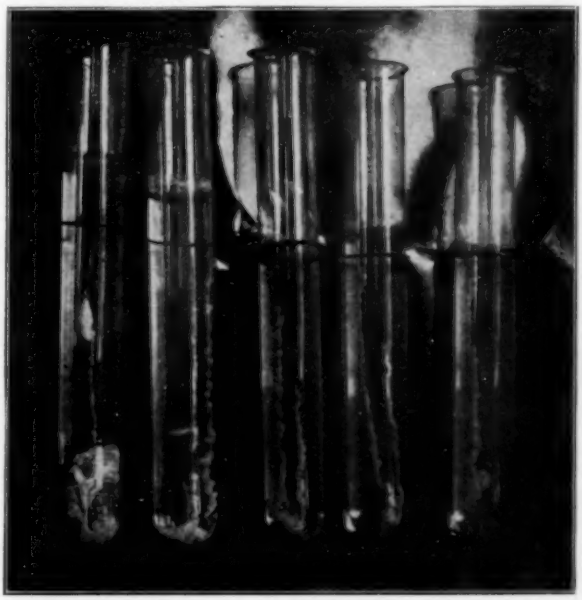
In the February number of the *Technical World* appeared an article entitled, "Is Science's Dream Realized?" The subject-matter was concerned with chemical plants produced by Professor Leduc of Nantes, France. The article was illustrated by these so-called plants which do, roughly, resemble some water plants at various stages of growth. A sample experiment for producing these plants was also given as follows:

"A small artificial seed about one-sixteenth inch in diameter is immersed in a solution of potassium ferrocyanide, sodium chloride and gelatine, varying from one to ten per cent. The seed consists of two parts simple cane sugar or saccharose and one part of copper sulphate."

This stimulated the following investigation of the "plants" as to their relation to organic life and as to the possibility of the development of organic life from inorganic sources. Seeds were first made from copper sulphate and cane sugar, copper nitrate and cane sugar, copper chloride and cane sugar, and from the sulphate, nitrate, and chloride with grape sugar. These were "planted" in solutions of potassium ferrocyanide, with and without salt and gelatine. Then seeds were made from potassium ferrocyanide and granulated sugar and others with the same salt and grape sugar. These were planted in solutions of the sulphate, the chloride, and the nitrate of copper. The plants were obtained from all the aforesaid combinations.

When potassium ferrocyanide is brought into the presence of a copper ion from a salt of one of the strong acids, a dark brown precipitate of copper ferrocyanide is formed. This substance has for some time been used, when deposited in the walls of porous earthenware vessels as a semipermeable substance, to determine the osmotic pressure of sugars, etc. There is no reaction between cane or grape sugar and potassium ferrocyanide. Hence when a "seed" composed of a mixture of a copper salt and sugar is introduced into a solution of potassium ferrocyanide it is immediately enveloped in a coat of copper ferrocyanide, which functions as a fragile semipermeable membrane. Then the solution tension of the sugar soon exceeds the strength of the membrane and through the rent in the coat of copper

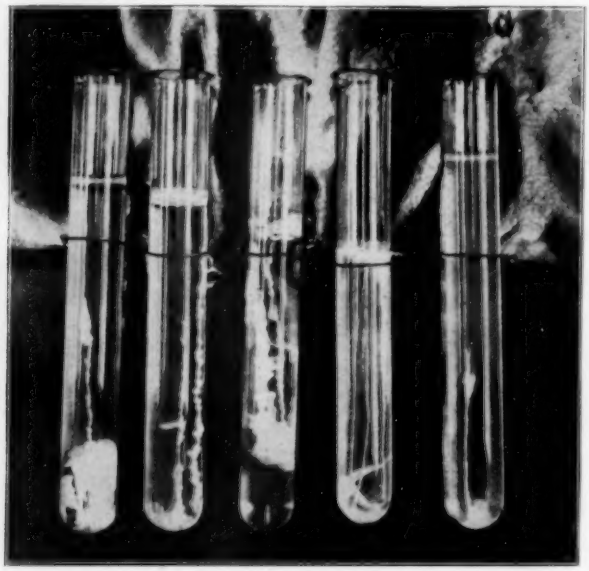
ferrocyanide enough sugar and copper solution flows to equalize the pressure and a new deposit of copper ferrocyanide mends the old coat and the process begins afresh. The next time, however, that the osmotic pressure exceeds the tensile strength of the seed jacket there is a decided preference as to where the break shall take place. That is, of course, near the end of the latest formed part of the membrane. That growth almost invariably proceeds upward evidently because the density of the inclosed solution is less than that of the outer one. This tendency is not so marked in case the seed is composed of potassium ferrocyanide and sugar planted in copper solution.



The essential feature of these pseudoplants is, therefore, seen to be a salt within the seed that will react with the salt in solution to form a membrane about the rest of the seed which admits water but is comparatively impenetrable to the substance constituting the remainder of the seed. The use of gelatine may be very misleading. It is by no means a culture for the plants in the sense of feeding them. If anything, it retards the growth but upon cooling it forms a media that will support the fragile stems and protect them from the currents started in the liquid by moving the vessel containing them. The sodium chloride could possibly aid in the reaction as a catalytic but could scarcely serve in any other capacity.

By trying the other metals with potassium ferrocyanide it was found that only zinc and cadmium gave results similar to copper. These give pseudoplants of a white color because zinc and cadmium ferrocyanide are both white. These pseudoplants have much more the appearance of plant forms than their copper cousins, but fundamentally nothing nearer the nature of real plants.

Occasionally there is a leaf-like projection in a horizontal plane beside the vertical stem that is hard to account for. These occur more frequently when cadmium is used than with zinc or copper. It is, however, hard to see how these can have an relation to the stem growth.



There is another variety of chemical plant which may well be mentioned in connection with this species and that is the crystal variety to which lead and copper "trees" belong. Sulphur can also form beautiful yellow "trees" with a cauliflower-like top. Iodine vapor solidifying forms blade-like crystals to which the nickname iodine "grass" is appropriate. These forests and meadows outwardly remind one of real plants but no one with the slightest insight could be guilty of suspecting that relation was closer than that outward appearance. Further, they bear no close similarity to the plants whose walls are composed of copper or zinc or cadmium ferrocyanide.

To draw a close comparison between the pseudoplants and organic life we shall have to consider material changes and energy changes involved in the growth of each and mark the points of similarity and difference, after which we may draw our own conclusions in regard to "seaweed produced from artificial seed" and the other "forms of artificial plant life."

First, it is needless to comment on the fact that yellow prussiate of potash and blue vitriol, or the other salts used, are poison to organic life when present in any quantity. Next, if we bear in mind the fact that gelatine is only used for the purpose of supporting the fragile stems and shapes and that it can have no relation to the growths as a food, we shall not be befogged as to the use of this material which is so often used as a culture for real organisms.

Second, all organic life grows by processes involving oxidation or reduction; chlorophyll-bearing plants by the latter, and other living things by oxidation. In the pseudoplants there is no chance for either.

Then as to the energy transformations involved. Reducing plants absorb heat and oxidizing beings evolve heat. The pseudoplants absorb heat from the surrounding liquid to carry the sugar further into solution. They grow by energy which is limited by the amount of sugar used and the growth is in turn limited by the energy, and therefore no chance for continuity and no reason to expect the phenomenon of reproduction. Whereas, organic life has unbroken continuity and simply corrects its mistakes and gradually eliminates undesirable features by death, thus manifesting unlimited potentiality.

Last, as to the one point of agreement, namely the osmosis of liquid through semipermeable membranes. At almost every point in the functioning of organic beings the principle of osmosis or solution tension is met with. Assimilation of foods, respiration, secretions and excretions involve osmosis. Pseudoplants have here a point of contact, but only a point because they absorb but one thing, namely, water. Any of the sugar that passes through the walls is lost to the pseudoplant while foods that do not pass through the walls of the intestine would be loss to an animal. To resort to analogy, the reasoning that confounds real and pseudoplants because both involve the principle of osmosis, would also confound a landslide and a waterfall because both involve the principle of gravity.

Since the modern flood of evolutionary thinking has broken over the once unsurmountable barriers between the species of living beings and has reduced organic life to a unity, it has dashed on in the attempt to unify the animate and the inanimate. Much work has been done pro and con. When micro-organisms were found in hay tea after a few hours of time, the immediate conclusion was that the spontaneous origin of life was proved. When this was refuted by sealing the sterilized culture and finding no germs produced, opposite opinion prevailed. It has been suggested, however, that with its capacity to form numerous compounds the carbon atom under favorable conditions may have woven an unstable compound which proceeded to ally other atoms at a rate which corresponded to the rate of decomposition, thus giving a foundation to secretion and excretion. Some arguments might be offered in favor of this view but they would leave it as they found it—mere conjecture. And the arguments opposing avail no better. In short the question is not likely to be settled in either direction soon, for to expect the laboratory production of organic beings with anything comparable to the powers and functions of those which it has taken the universe infinite time to produce is a colossal presumption. And as for the question as to whether living beings developed from inorganic sources or not, we can see nothing whatsoever in copper, zinc, or cadmium ferrocyanide "sea weeds," in copper and lead "trees," sulphur "bushes," or in iodine "grass," to prejudice a man one way or the other; nor is there anything in them to substantially confirm an already existing prejudice in either direction.

A CAMERA AND OBJECT HOLDER.

By H. Clyde Krenerick,

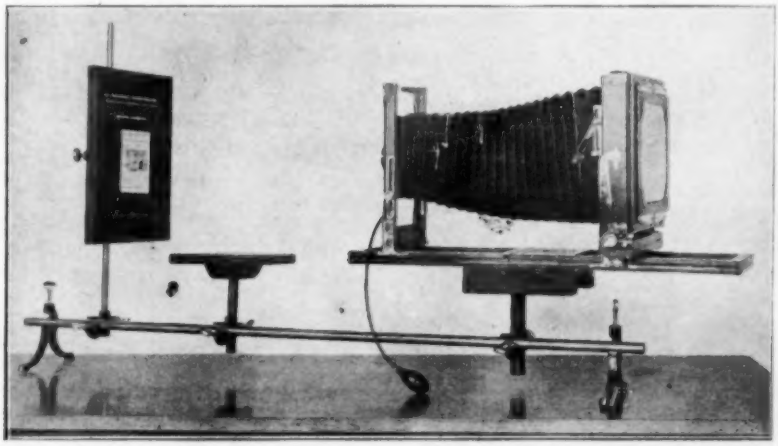
North Division High School, Milwaukee, Wis.

Those who use the camera to copy diagrams or prints from various sources for projection purposes have felt the need of an adjustable device for holding camera and object. I have found the apparatus shown in the accompanying print a very satisfactory solution of the difficulty.

If the laboratory is equipped with support rods and clamps, the apparatus can be easily and quickly constructed and with no extra expense. The horizontal support or bench is our lab-

oratory optical bench consisting of the two end supports and a 120 or 180 centimeter cross support rod. The clamps for holding the vertical supports are right angle pieces of two V openings.

The camera table is constructed of two blocks glued together, through which has been cut a circular opening large enough to admit the top of an ordinary camera tripod. On the top of this there is glued a third block of such thickness that the thumb screw of the tripod will pass through it and into the screw receptacle in bottom of camera.



The object holder is a ten by twelve inch board, through which have been sawed two three way grooves, one within the other. The single board thus serves as three of different widths, over any one of which can be stretched rubber bands. Cardboards or papers are held in a vertical position by means of rubber bands near the upper and lower edges.

When copies are made from diagrams or pictures in books, the adjustable stage is clamped just in front of the vertical object board. A part of the book rests horizontally on the stage, while the other part with subject to be copied on the outer page is held against the board in a vertical position by means of the rubber bands.

It will be seen that all possible adjustments for both camera and object are provided and can be easily and quickly made. If the square form of support rod is used for the bench, the camera, stage, and object holder will always be in line. This in some cases, however, will be a disadvantage.

A METHOD OF PREPARING STANDARD SOLUTIONS.

By L. B. Altaffer,

West High School, Cleveland, O.

In making up standard solutions, trouble is met in trying to get exactly normal and decinormal solutions so as to avoid factors. The following method I worked out some twelve years ago and it has been used constantly in my laboratory since that time.

It is necessary to have an accurate solution to start with—preferably a normal sulphuric acid solution, carefully made and tested. After this is obtained, the supply of alkali and acid solutions can be kept up easily.

Method. Suppose we wish to make up a normal sodium hydroxide solution. Prepare two solutions of the alkali—one *stronger* and the other *weaker* than the one required by weighing roughly on trip scales say 45 gm. and 36 gm. NaOH and dissolving each in about a liter of water. Have two burettes ready and fill with the two solutions and titrate each carefully against 20 cc. of the standard H_2SO_4 solution, taking the mean of three determinations each. Suppose it takes 12 cc. of the stronger and 27 cc. of the weaker solution. Then by alligation one can determine the ratio between the number of cc. of each that must be mixed to make a solution that will be exactly normal, as indicated below:

cc. acid	cc. alkali	difference	
20	12	8	$12 \times 7 = 84$cc. stronger
	27	7	$27 \times 8 = 216$cc. weaker

As shown above, the *stronger* solution *lacks* 8 cc. of water while the *weaker* has 7 cc. too much; hence to even up, take 7 times 12 or 84 cc. of the stronger to 8 times 27 or 216 cc. of the weaker. This is in the ratio of 7 to 18; knowing the amount of each solution made up, one can easily figure out how much of each must be taken to use nearly all of one and the proper amount of the other.

Proof. In a normal solution of H_2SO_4, each cc. contains .049 gm. acid equivalent to .040 gm. NaOH. Hence the 20 cc. used in titrating will contain .980 gm. H_2SO_4 equivalent to .800 gm. NaOH. In the stronger solution this .80 gm. NaOH is held by

the 12 cc. while in the weaker, it is held by the 27 cc. Therefore 1 cc. of each will have .8/12 gm. and .8/27 gm. of the alkali respectively and the ratio number of each will hold as follows:

$\frac{.8}{12} \times 7 = .4\frac{2}{3}$ gm. in 7 cc. of stronger,
$\frac{.8}{27} \times 18 = .5\frac{1}{3}$ gm. in 18 cc. of weaker.

Hence,

1.00 gm. in 25 cc. of the mixture,
.040 gm. in 1 cc. of the mixture,

and

.800 gm. in 20 cc. of the mixture.

Since sodium hydroxide and potassium hydroxide cannot be weighed accurately, the advantages of this method are obvious.

After getting one alkaline solution, this can be titrated against to prepare other acid solutions in exactly the same manner. It is not advisable to use less than 20 cc. of the standard in titrating.

Having the standard acid solution to begin with, the other chemicals need not be C. P. since they are weighed but roughly.

SOME SIMPLE ELECTRICAL APPARATUS FOR CHEMISTRY.

By A. E. Parkins,

Holland High School, Michigan.

From a brief examination of the different text-books in use in our high schools to-day, we readily see that the question of how much electricity should be taught in connection with the subject of chemistry is not well settled. I have left such a question out of consideration. The following apparatus were designed to accompany Newell's Descriptive Chemistry.

1. *A Cheap Voltaic Cell.* In order that the pupil may understand the voltaic cell as well as he should, it is highly essential that he become acquainted with it by actual use. For a large class this requires a large number, and when purchased ready made means considerable expense. For the last two or three years we have been using a cell made by the pupils which costs so little that individual ones may be had if need be.

The jar is made by breaking off the top of a bottle by means of a cord or yarn saturated with some combustible like kerosene or turpentine. The yarn is tied around the bottle where

the cut is to be made and ignited. After the flame becomes extinguished the bottle is held beneath a stream of water so that the water will come in contact with the heated portion.

The positive pole is the carbon from a wornout dry cell. The negative is a rod of zinc the kind used in a salammoniac cell. Strips of sheet zinc would be cheaper. The binding posts of carbons in dry cells could be used for connection here. The electrolyte may be any of the ordinary solutions. Such a cell with a chronic acid solution produced over five amperes and an E. M. F. of over three volts. The poles are held to the sides of the cell by wire clips.

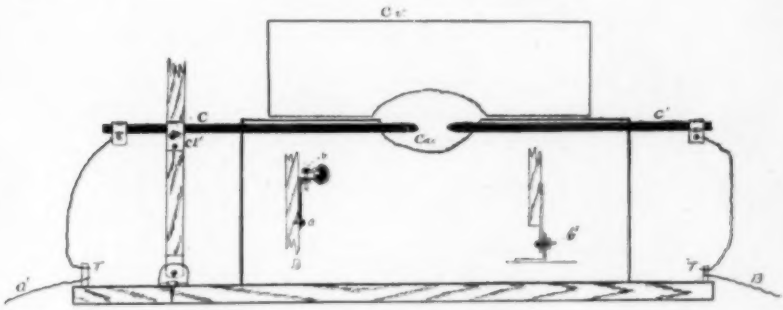
2. *To Show the Conductivity of Solutions.* It will be found that "Conductivity of Solutions," "Ionization," and "Electrolytes" will mean more to the pupil if the following apparatus is used: Two platinum electrodes are sealed in glass rods of about five inches in length. These prepared electrodes are held in place by a two hole stopper. These electrodes are connected to the incandescent light system. The current should be an alternating one to prevent electrolysis and passed through a lamp to reduce it. This lamp also serves as an indicator. The solutions to be tested are placed in test tubes. The electrodes supported by the rubber stopper are thrust into the solution. If the conductivity is good the light burns brightly. The electrodes should be rinsed before inserting into the next solution.

The results are only rough, of course, but by using care in selecting the solutions the experiment will prove helpful and interesting. An ammeter placed in circuit would help to decide doubtful cases.

3. *A Small Electric Furnace.* The accompanying cut shows the cross section of a small electric furnace made from a description of the Moissan furnace. In this one the brick and lime cavity are replaced by a block of limestone about 5x5x9 inches. In the top face of the base is hewn a cavity about 1x1x2 inches, also two longitudinal grooves to receive the carbon electrodes.

The cover is a similar stone with a cavity hewn in its lower face. Both base and cover should be bound with a piece of sheet iron or tin to keep the pieces in place should the heat be great enough to crack the stones. The carbons are regulated by means of the vertical lever, hinged at the base and attached to the carbon by means of the clamp Cl′. This clamp is attached to the lever at one place only, *a*. This allows sufficient horizontal

movement. The electrodes are connected to a lantern circuit (alternating current 212 volts) by means of clamps. These clamps and other metal work are made from sheet aluminum—easy to cut and easy to shape. The bolts used are short stove bolts.



In such a contrivance calcium carbide, calcium phosphate, phosphorus, brass, and alloys are easily prepared.

Calcium carbide requires intense heat; the cavity should be small. Gas carbon or powdered arc light carbon is best to use.

Calcium phosphide is prepared by heating calcium oxide, carbon, and red phosporus. The phosphorus is placed in first in small quantities; this is covered by the other ingredients well mixed and pulverized. Some kinds of animal charcoal and calium oxide will produce calcium phosphide.

Phosphorus is prepared as directed in Newell by heating a phosphate, charcoal, and sand. Phosphorus is separated and burns at the top. It sometimes sublimes on the faces of the stones and bursts into flame when the cover is lifted. The glass like slag remains in the furnace. This is exceedingly hot. Pieces of porcelain are easily melted when pushed into this plastic mass.

Brass is easily made by heating zinc and copper. The stones may be obtained from the refuse heap at a stone cutter's. The corner of an old ax will prove a good instrument for cutting the grooves and cavities.

Shipments of tungsten ore are now sent out from the Deer Trail district of Stevens County, Washington, to the Krupp steel works in Germany. The ore is first concentrated to a rich matte product on the Pacific coast.

APPARATUS FOR INSTRUCTION IN GEOGRAPHY AND STRUCTURAL GEOLOGY.

PROFESSOR WILLIAM H. HOBBS,

University of Michigan.

II. MOUNTAIN STRUCTURES.

Practical structural geology is essentially an exercise in synthesis, but one which must often be carried out with many of the needed elements missing. In order intelligently to set forth from the incomplete data the actual dispositions and attitudes of the rock layers a consideration of the types of warped surfaces into which rock layers are thrown in the process of folding is first of all essential. Where abrupt variations are noted from the curve demanded by the greater number of observations, some special explanation in rock rupture, or faulting, is called for.

Though the student may be shown photographs of anticlines and synclines of the various types as these are illustrated in single rock cliffs or ledges, it is as well that he should know at the outset that these are only rarely to be thus observed, and that nearly all which we know of the nature of rock folds is derived from a process of patching together in which the scattered observations of dip, strike, and pitch furnish the elements.

The difficulties in the way of making clear to students the nature of the dip and strike of rocks, have convinced the writer that the only satisfactory method is to give each student a practical drill. Educational institutions which are situated in areas of folded rocks have the best of all opportunities because the class excursions can be utilized for a study of the strike and dip. Very large numbers of students are found, however, in regions where rock beds lie relatively flat, and still others, like those at the University of Michigan, are surrounded by such thick deposits of glacial material that a journey by rail of a couple of hours is necessary in order to find rock exposed at all. Obviously, then, there is the necessity of supplying laboratory drill in structural geology as a preliminary to studies in the field. We are of the opinion that even where the best of conditions for field study exist, the laboratory drill as here outlined may be made a valuable adjunct to the excursions.

In order to permit of suitable studies of rock position and attitude, a special laboratory table must be used. For this purpose

one of the ordinary type is constructed, but with a separate top which may be taken off whenever the table is to be used for structural studies. Thus denuded of its usual cover, the table presents a top of soft wood painted like a blackboard and divided by narrow white stripes into square sections which can be numbered with chalk on the township plan. In Figs. 1, 2, and 3 such tables are shown in use with the tops removed. In Fig. 1 one of

Fig. 1.—Laboratory tables in use for studies of mountain structures. The nearer table to the right is arranged to illustrate the relation of varying strike and dip to pitch. The nearer table to the left shows a series of outcrops outlining an unsymmetrical pitching anticline. The farther table to the right illustrates the common types of rock folds. The farther table to the left shows a series of outcrops which illustrate how faults produce offset.

them appears in the foreground with its usual cover, and in Figs. 1 and 3 the removed covers are seen standing against the wall of the laboratory near the entrance door. These covers are strongly braced with cleats and have a flange which fits over the edge of the inseparable top of the table so as to be maintained in position. It is well to place the tables, at least when they are in use for structural studies, so that the section lines correspond to the cardinal directions.

To represent the rock outcrops in the laboratory studies a simple device which we may call an "outcrop block," has been constructed. This block, which is shown in Fig. 4, is made by sawing out from ⅞ inch board a rectangle four inches by six, and

then sawing from the middle of one of its narrower edges a rectangular piece one and a half inches deep and two inches broad. This piece is slipped down from its former position within the larger block so that it projects by one-fourth of an inch. A ¼ inch hole is then bored through both pieces, keeping to one side of

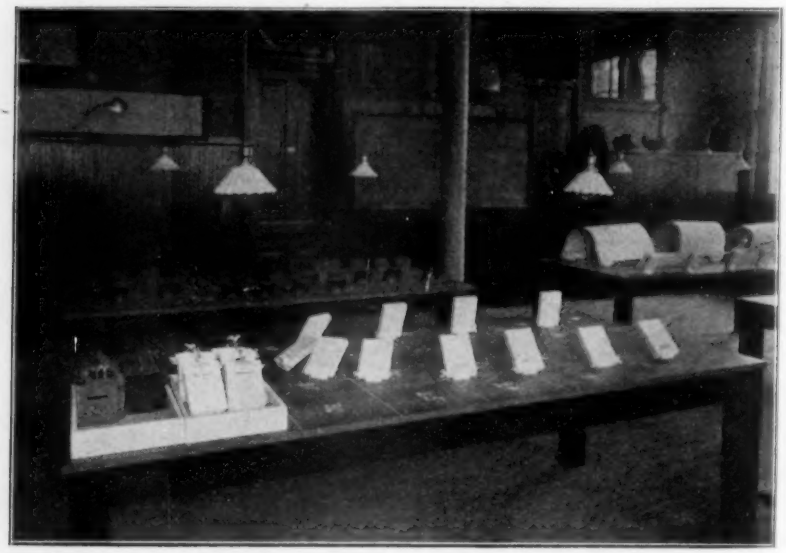


Fig. 2.—View of the special laboratory table with sections numbered on the township plan and exhibiting a series of outcrops which outline an unsymmetrical pitching anticline. The more distant table to the right exhibits the common types of rock folds.

the medial plane of the board, and a bolt provided with a washer and wing-nut passed through and fastened. A similar but shorter bolt is passed in a direction at right angles to the first and toward the other side of the medial plane through the smaller block, the rounded head of the bolt being accommodated in the free space left between the two blocks. The outcrop block as thus constructed is fixed in any position upon the table by merely boring a hole in the top of the table with a ¼ inch bit and passing the projecting portion of the bolt through it. Before tightening the wing-nut the block may be given any desired azimuth (strike) in reference to section lines, which through adjustment of the table have already been made the cardinal directions. By first loosening and then tightening the wing-nut of the horizontal bolt each outcrop block may be given any desired inclination (dip). The broad surface of the block thus represents the surface of a rock layer in the exposure. The position of each block may be

described in terms of its distances from the boundary lines of the numbered sections. The blocks are painted, some white and others Venetian red, so as to represent the different petrographic types—let us say, limestone and red sandstone. A square form of outcrop block four inches on an edge looks somewhat better and is in most respects quite as satisfactory as the larger one, but a compass needle is apt to be affected by the iron bolts when a measurement of the strike is made. Some of the blocks shown in the views are, however, of this size.

Fig. 3.—Laboratory table arranged to show how faults in different positions offset the lines of outcrop.

An almost infinite number of demonstrations and exercises are possible with the use of this simple apparatus. The various types of synclinal and anticlinal fold—symmetrical, unsymmetrical, and overturned—may be shown in comparison by fastening pieces of stout paper to the outcrop blocks by means of thumb tacks (see Fig. 2 at right), or they may be illustrated successively in a single fold through adjustments in the dip. The relation of strike and dip to pitch, so difficult to make clear in the absence of models, is here rendered comparatively easy. In Fig. 1 at the right toward the front, a group of outcrops of limestone and overlying sandstone betrays an anticline pitching south (to the left). To bring this out clearly a piece of stiff paper is fastened by thumb tacks to the limestone outcrops and thus restores the

missing portion of the fold—the "air saddle." For such a structure the paper is not competent to support its weight, so a strip of poster board is fastened beneath it in the broad portion of the arch attached by brass rivets such as are in use for paper fasteners (the McGill type). The relation of the varying strike and

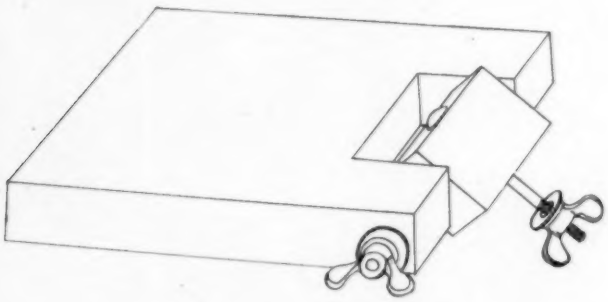


Fig. 4.—An outcrop block.

dip to the pitch is seldom grasped at a glance, and the student is therefore required to measure and record the dip and strike as well as to determine the location of each outcrop, in order to prepare a map on the basis of his observations. This map is afterward compared with the model (see Fig. 5). Small clinometer compasses are provided for this purpose and the strike observation measured at the top of the block as far as possible from the iron bolts. The observations are taken down on section paper so as to locate each outcrop without the necessity of written notes, the strike and dip being indicated by the T-shaped symbols of Dana. A practical problem in the form of a steeply pitching unsymmetrical anticline is represented on the nearest table of Fig. 2, and in the students' notes by Fig. 6.

How the process of folding in rocks shortens the crust and distorts or deforms the beds themselves through the accommodation of layers, is forcibly brought home to the class by the simple device illustrated in Fig. 7. This model is prepared by sawing from a three-inch plank a strip one inch wide in the form of an unsymmetrical anticlinal fold. Two exactly similar piles of strips of white paper an inch in thickness and of the same length as the straightened anticline, are marked on the long edge with a series of tangent circles provided with vertical and horizontal diameters. These circles may represent any structures within the rock beds; let us say, the pebbles of a conglomerate. On placing now one of

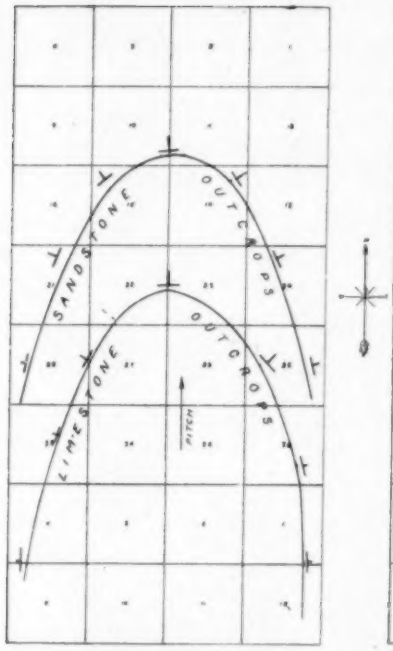


Fig. 5.—Students' map of outcrops to show the relation of strike and dip *to* pitch.

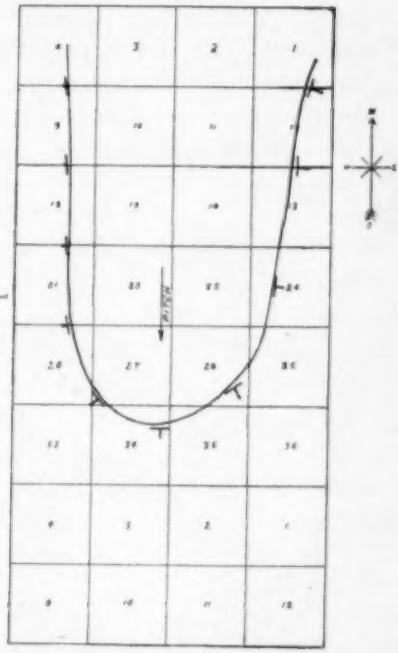


Fig. 6.—Students' map of outcrops which outline an unsymmetrical, pitching anticline.

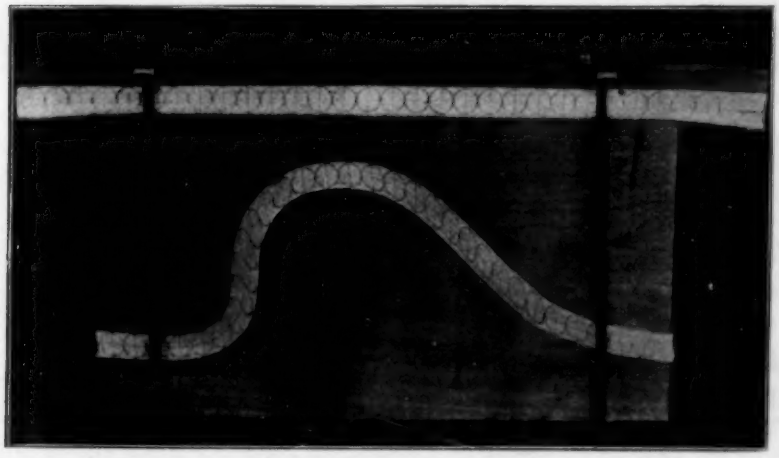


Fig. 7.—Model to illustrate the contraction of the crust and the effect of accommodation between layers in the deformation of rocks.

the piles of paper in the space cut out from the plank and fastening the two parts of the model together, except within the arch of the folds the circles are changed into ellipses through the accommodation of the sheets of paper just as they would be in rocks through accommodation of the rock laminæ. The greater distortion occurs in the steeper limb of the fold, and the axis of greatest distortion or slide is that which in a more extreme case of folding—a sharply overturned anticline—would develop into a plane of rupture or thrust. The amount of crustal shortening is here indicated by placing the unbent pile of paper beside the folded one. Thus all these more or less complex changes within the rocks in the process of folding are given a striking demonstration without the resort to mathematical treatment. The student thus learns why, if he is searching for a conglomerate in a region where the rocks have been complexly folded, almost his only chance of finding it is to search in the arches of the anticline where the pebbles have been so little changed as to be still recognizable.

To illustrate the subject of faulting the writer has already described a piece of apparatus[1] in which wooden blocks of different sizes are floated upon water and held in unstable positions through the medium of a vice, so that when the compression is released they at once adjust themselves to their natural positions of flotation to the accompaniment of faulting. The swelling of the wooden blocks used in this experiment soon gave trouble in operating, and the apparatus has since been much improved through the substitution for the wooden blocks of small boxes made from galvanized iron.

The outcrop blocks which have been described above can be used to especial advantage in illustrating the subject of faulting, and particularly the effect of faults in offsetting lines of outcrop. In Fig. 3 the manner of this offsetting is illustrated for faults which strike at right angles to the strike of the beds (the series to the right on the table) as well as for faults which strike obliquely to the strike of the beds (the series at the left on the table). The combination of faults with folds may here be made particularly instructive because the portions of the folds once above the present eroded surface may be restored in the paper arches for a clearer understanding of the subject (see Fig. 1).

[1] Earthquakes, D. Appleton & Co., New York, 1907, pp. 34-36, pl. 3

SCIENCE TEACHING IN SCHOOLS.

By Arthur S. Dewing,

Harvard University.

A study in the relation of science teaching to the general problems of education.

Continued from the October issue.

II. The Place of Science Teaching in Education.

If the importance of science teaching to the development of character is fully recognized it becomes another and no less important problem to determine the place of the sciences in any general system of education and the parts of science that serve best the purposes of education. In the first place it must be recognized that a well rounded mind rather than the mind of "one idea" is the general purpose of any teaching, and science cannot hope to monopolize, as many teachers would have it, any stage of educational development. The modern technical school which tries to turn men into machines has probably as pernicious an effect on character and that general poise which goes with the educated man as the old system of classical learning which developed pedants rather than men. Science teaching has its mission in general education, not by virtue of the "facts" which it teaches or even on account of the present fashion in education, but because these faculties of the mind which it is most essential to develop find a ready means of cultivation through training in the sciences. This training may be broad and bring the pupil into contact with other things. The notion that each subject of study is a unit in itself, a little universe with no connection with other subjects is deadening in the extreme. On account of the apparent technical character of the sciences this attitude appears there perhaps more than elsewhere. It need not be the case. Science may be taught so that it throws light on almost every phase of human interest. The pupil that studies the Hydra in the laboratory can be interested in the myths of Hercules and there is no better way of showing boys the "usefulness" of Greek, than to let them see how many technical terms came from the classics. Professor Richards once remarked to a class in chemistry that he thought every chemist should study Greek so that technical terms could have some kind of meaning to him. The student of botany may have his attention called continually to subjects far distant from

botanical technicaliities—what teacher could teach the tropisms of Mimosa without mentioning Shelley's Sensitive Plant! The English Language is unusually fortunate in that it is so rich in scientific classics. Why not use them as supplementary reading to the text-books? The styles of Darwin and Huxley are models of English prose but the student of botany is seldom encouraged to read in Darwin although he would find there a clearer account of such subjects as insect pollination or the irritability of plants than his teacher is likely to give him. The lives of the great scientists are just as significant for education as the things which they stand for. The sciences or the philosophy of man is in the end the expression of personality and the more students learn about personality the larger men they become. The place of science, then, in education is wherever it can be taught so that the minds of the students are developed and their outlook into life broadened.

The question of the time at which to begin to teach the sciences and the order in which they are to be taught is not of very considerable consequence. In early years the imagination is more receptive, more fluid than later and its breadth can be cultivated by stories of birds and insects as well as by magic charms and mermaids. There is a wonderful field open here, which we are only just beginning to appreciate. The child, like the savage is interested in things living. The cry of primitive man is for a fuller life and it is quenched only with advancing civilization. The development of the child is parallel to the development of the race. The child yearns for food for the imagination, and this may best be satisfied by the appeal to his other passion, the love of life. At first the nature study may be of the most imaginative character, it may only awaken an interest in the outside world without teaching anything more than that birds fly with wings or fishes swim with fins. But the germ has started. The child has had its attention directed toward the great world of living things and it is only some reactionary system of education in later years that can stifle its growth.

If simple nature study can be utilized to develop the imagination of children in the early years of the primary school, there is no reason why such training can not be pursued further in the intermediate and grammar schools. The science teaching need be neither exhaustive nor detailed but the same inductive spirit of instruction, usually described as the laboratory method,

may be introduced with great value to the general training of the mind. Botany and zoölogy afford the best material for sex instruction, and this is a task which the community seems to be shifting to the schools. These sciences, moreover, are relatively free from mathematical postulates, they require simple laboratory appliances and above all tend to strengthen the same interest in nature which the simpler more imaginative studies had brought into being. It is not improbable that studies in earth sciences could be introduced in the last years of the grammar schools but at the present time we are requiring so much of the grammar grades that it is perhaps a question if it were not better to do less and do it better.

The proper teaching of the sciences in high schools is of the greatest importance. Large laboratory facilities, at least an elementary knowledge of algebra and geometry, give the teacher an opportunity to make the science work a vital factor in education. It is probable that such sciences as botany—including many experiments actually performed by the pupil in plant growth and plant activity—zoölogy—with a due regard to ecology and modern theories of inheritance and biological evolution—and physiography with emphasis on the dynamic rather than the structural—should come early in the high school course. This will give the pupil an opportunity to become familiar with careful laboratory work and inductive methods before he is introduced to chemistry and physics. By postponing these two sciences until the last two years of the course the students will have had some training at least in algebra and geometry before they are called upon to apply mathematical conceptions to science. It is a great mistake to teach astronomy to those students who are not well fortified with mathematical training. In all these sciences the laboratory method, the spirit and not merely the letter, must be the dominating method of teaching. Any difficulties in applying it to science teaching, at any stage, are not to be met by relinquishing any of the ideals which it defines, but rather in demanding better preparation for the science teaching. The teacher of science must have definite ideals. These are identical with the high ideals of general education. Our purpose must not be to make our pupils prodigies of science or of learning, but to express how fully the purposes and results of science teaching accord with all that education deems of permanent and vital value.

Perhaps no single question connected with the place of science in education is of more importance than the point of view taken in regard to the relation of the empirical facts and the underlying principles. Specifically it is the problem of the relative position of memory facts in a system of general education. Shall science hold as its purpose the teaching of facts or the training of minds? Every subject rests on certain facts. These facts may be the direct result of experience as in the case of the sciences or they may be the general conditions of experience as in the case of mathematics. In any case, however, the facts of a subject are the necessary bases, and as such they must be taught. They are necessary for the understanding of the subject, but this is quite a different matter from declaring that the educational value of the subject taught depends on these facts. The contrary is the case. The learning of a vast array of facts gives to the student absolutely no educational value in the truest and the highest sense. The true value of a subject from the point of value of education is the understanding of the relations between these facts, the mental power required and fostered by drawing conclusions from the facts. Alone they serve as the raw material of the educational process. This material should be as little and not as much as possible. The aim of education should be the cultivation of the greatest amount of reasoning power with the least number of facts. In the end the material is only means, yet a necessary means, to the process. The kind of material used is insignificant compared with the kind of process cultivated. The thing for science teachers to observe constantly is that the learning of an array of facts, no matter how significant in themselves, is unimportant compared with cultivation of mental power brought about by the intelligent understanding and employment of these facts.

There is another matter connected with the value of the facts themselves which has an important bearing on science teaching. No pupil can learn all that is to be known in regard to a subject—even if the teacher were in a position to go thus far—and it becomes necessary to distinguish the facts thoroughly worth while. If what has already been suggested in regard to the insignificant value of facts themselves is correct, then it is obvious that as little energy as possible should be expended on the mechanical process of learning them. No facts should be learned which are not to be connected together in some way so

as to increase the pupil's powers of comprehension. It is useless, for example, to teach that the height of the barometer is ordinarily thirty inches of mercury unless this fact is understood by the pupil to illustrate a single phase of the general theory of fluid pressure. It would be far better to teach the pupil a little something about fluid pressure than numerous facts about barometers and pumps and siphons, with the result that he understood nothing about the principles upon which these facts depend. The first rule therefore in selecting facts to be taught is that of having as little waste as possible. Make every fact mean the most that it can and select the facts according to the relative amount of meaning that the teacher and the pupil can inject into them. And there is another rule like in kind to this. Let the facts have as general a value as possible. If a single fact can be used in several connections it is certainly more worth while for the pupil to remember it than some other fact having but a restricted significance. Likewise if a fact is useful for the pupil in several studies it is certainly more worth while to learn than some other fact which is useful to him in but a single study. Briefly, then, it is well to remember that the teaching of things of mere fact-value should be done with as little waste as possible and with a view to have the few facts that are learned have as broad a range of meaning and usefulness as possible.

This suggests the other important problem for science teaching —the means by which the sciences may be taught so that they will contribute most to what is worth while in education. The method of science teaching must be the method of induction. The student must be made to see at all hazard the perspective value of the fact and its theoretical significance. There is a theory of logic which makes all reasoning a process of subsumption, a process of subsuming a particular term under a more general expression. Whether or not this is a correct account of the reasoning mechanism of the mind, it is at least a fairly accurate description of the practical method by which the sciences ought to be taught.

(*To be continued.*)

WHAT KNOWLEDGE (OF PHYSICS) IS OF MOST WORTH?*

FRANK B. SPAULDING,

Boys' High School, Brooklyn.

I have no anticipation of giving a final answer to this very important question. The correct answer to-day will be incorrect to-morrow. The correct answer for me will be incorrect for you. The correct answer for one school will be incorrect for another school. So long as we maintain mental life we must keep up the processes of selection, assimilation and elimination which are necessary to all life. It is indeed this very lack of finality which makes it important that we frequently consider whether our practice is consistent with our ideals and whether both ideals and practice are justified by the conditions under which we work. With this end in view, I take the liberty of offering some criticisms upon our present procedure and a few suggestions as to means of improvement. The criticisms are aimed quite as much at myself as at anyone else and the suggestions are mere personal opinion. Their purpose will be accomplished if they provoke general discussion and interchange of views among the members of this club.

There are three ideals, distinguishable but by no means distinct, which have successively dominated physics teaching and which influence in varying proportions our present practice.

The first in historical order we may designate as the classical because both in aim and in method it reflects the influence of classical teaching. It is characterized by a centering of the attention upon the subject rather than the pupil. Its aim is a rather vague general culture, to be attained through the acquisition of a certain fund of knowledge, knowledge of which no educated person can afford to be ignorant. It conceives of physics as a rather definite body of such knowledge, and in imparting the same uses to great extent the direct avenue of the memory. Probably we are all more influenced by this ideal than we realize. Our traditions, our examination systems and our very interest in the subject matter which we teach tend to perpetuate this influence. Some excellent and popular text-books like Carhart & Chute and Hoadley strongly reflect this ideal.

The second ideal, the technical, found its way into the high school from the great universities through the influence of uni-

*Read before the Physics Club of New York.

versity trained teachers and entrance examinations. The spirit of science, they say, is the spirit of investigation. To teach science, therefore, is to train in methods of scientific investigation. It is to this ideal we owe our laboratories, our accurate measurement and most of our mathematical problems. The text-book of Hall & Bergen conforms closely to this ideal and Avery is much under its influence.

The third ideal, which assumes the title of modern, numbers among its exponents Mann & Twiss and Millikan & Gale and our own Mr. Woodhull. However various the language they speak, they unite in focusing the attention upon the pupil rather than the subject, in attempting to bring the subject to the pupil, not the pupil to the subject. The aim is to interpret to the pupil his daily experience. Instead of presenting fundamental laws meagerly illustrated by experience, the laws come as crystallizations of many experiences.

Without, I hope, losing sight of whatever is good in the two former ideals, there is a strong tendency at present among physics teachers in the direction of the *last*. We continue to teach with a view to general culture, but we realize that the largest measure of culture and the best kind of culture is obtainable from the study of those things which have a bearing on the actual life of the pupil. We do not fail to recognize the value of accurate observation and measurement, but we realize that only one in a thousand of our pupils is going to become a scientific investigator. We are coming to regard it as our first duty to give our pupils some appreciation of the physical world in which they now live, to interpret to them their daily experiences, to acquaint them in some measure with the many commercial and domestic applications of physical principles which come under their observation.

I have said that this tendency is strong among physics teachers; it is not so apparent among the various authorities who map out our courses and set our examinations. These still follow rather closely the recommendations of the "Committee of Ten." I am not inveighing against state and college entrance examination systems. They have done and are doing a great educational work; they spur the lazy, inspire the indifferent, and restrain the vagrant. They are necessary to the maintenance of any standard of scholarship; but their tendency is conservative. They follow rather than lead in pedagogical progress. Moreover, wherever schools, teachers, pupils are measured by the

results of outside examinations, there the subject not the pupil will receive chief consideration; there the appearance of knowing will often take the place of real knowledge. It is indeed a very difficult problem to construct examinations which shall be a stimulus to scholarship and at the same time give free play to local and personal needs. Our various examining boards recognize this in giving optional questions. They have certainly gone far enough in that direction. The next step should be to offer different examinations for different classes of students and different grades of work.

In respect to courses in physics, we are just about where the "Committee of Ten" left us some fifteen years ago. We are working on the assumption that all high school pupils, regardless of sex, tastes or prospects, need a prescribed one year course in physics and no more. Indeed the assumption goes farther. A large majority of the subcommittee or "conference" of the "committee of ten" were college professors, and the course they laid out is obviously a course intended for *boys* preparing for *college*. Now there was a time, not so many years ago, when all secondary education was college preparatory, and only boys went to college; but that time is past. At present girls constitute a majority of high school pupils and only a very small minority of our pupils are going to college. I have no argument to offer on the subject of sex *equality;* but I am far from believing in the mental *identity* of the sexes. The normal girl's interests and tastes, her fund of observation and her method of approach to many subjects are different from those of the normal boy. In the study of a language these differences may be negligible, but not so in the study of a science, especially physics. I speak with some diffidence on this point in the presence of those whose experience in teaching the subject to girls is much wider than mine; but I have had the injustice of the situation brought painfully to my attention recently through association with a pupil of a neighboring school. From her report and the remarks of teachers of girls, I judge her case is not an unusual one. With no interest in things scientific, no fund of observational knowledge and no ability to think in mathematical terms, she has tried with most commendable perseverance to *remember* how to do the various *"stunts"* which are likely to be called for in the coming Regents' examination. To her they will never be anything but "stunts." At first I tried to make them intelligent

processes, but they are so remote from the world in which she lives that though she may for a moment catch a glimpse of their significance, it is only for a moment and then only the process remains. What interest can she be expected to have in specific heat, the principle of moments, the distance a falling body traverses in a given second or the relation of the time of vibration to the length of a pendulum? She has made a fairly creditable school record thus far and will probably pass the examination, but what does she really know of the subject? What mental possessions has she to show for these many hours of the most taxing effort? A hundred definitions, fifty general laws, seventy-five formulas for solving problems—all the *husks* of knowledge, none of the *grain*. Occasionally her teacher frankly says to the class, "This is too hard for you; I do not expect you to think these problems out, but they can all be solved by the use of this formula," and then he proceeds to give for example, "mass$\times$specific heat$\times$change of temperature=mass'$\times$specific heat'$\times$change of temperature." Could anything be better adapted to extinguish thought? There are, perhaps, those who will claim that the girl has received some mental discipline in this process. If she has, I am sure it is a training in intellectual slavery if not in intellectual dishonesty. Yet there are physical phenomena in abundance and physical principles which she could study with great profit. The attempt to force her through a course designed for boys in preparation for college is nothing short of a *crime*. I have said as much both to the girl and her mother, but what can she do? To give up physics is to give up graduating and thus give up the hope of becoming a teacher.

As I said before, our course is not only adapted to boys but to boys preparing for college. Yet only a small minority go to college. The future which we should have in mind in choosing our material and methods is a future in the office, the factory, the field or the household.

But the present uniform course not only results in dragging some pupils through work for which they are wholly unqualified; it is entirely inadequate to the needs of others. Every term in our school we have boys asking for advanced work in physics. Generally it is merely interest in the subject which prompts the demand, but occasionally it is for preparation for some line of business or advanced study. Whatever the reason, these boys ought to have the opportunity which they seek. Here the more

complex and more mathematical features of our present course would find their proper place. Here the fundamental principles of mechanics, heat and electricity could find such varied, frequent and definite application as to make their knowledge real sources of power. Here some conception could be gained of the fields of knowledge opened up by recent investigation.

Why should not this organization do something to persuade the city and state authorities to offer an elective advanced course in physics? I am sure, were such a course offered, in our particular school its classes would outnumber those in Greek five to one.

But without waiting for radical changes in the conditions under which we work, there are some things which we can do in the direction of adapting the work to the varying needs of our classes. That is, the teacher, for the benefit of his classes may take advantage of that margin of optional questions instead of feeling obliged to cover the whole syllabus leaving the margin to the pupil. Let me offer a few illustrations:

Capillary phenomena are interesting and worth some attention, but why should pupils memorize the laws of capillarity?

Does not the subject of density occupy an amount of time quite out of proportion to its importance?

No course in physics could afford to omit Newton's law of gravitation, but can you wonder that pupils feel that finding the weight of bodies 4,000 miles above the earth's surface is a little far fetched?

Only a few of our pupils really grasp the significance of absolute units; a larger number merely remember "$f=ma$" and "grams$\times$980=dynes;" the rest give it up. Shall we give it up, too?

What has been said of absolute units might also be said of calorimetry and index of refraction.

In laboratory work, why not omit all measurement merely for the sake of teaching manipulation or method? These are never ends in themselves and are much better taught if employed in the actual search for truth. To illustrate: The recent discussion in regard to our navy might well suggest the question of predetermining the water line. Instead of the usual determination of the density of a block of wood by measuring and weighing, discuss the question of water line, let the pupil measure and weigh to determine it and then test his result by floating the

block. Mr. Packard gave some excellent suggestions along this line at our last meeting. I will add only one more. One of my classes last term, instead of the usual exercise on the photometer, measured the candle power of an incandescent lamp at different pressures from 80 to 120 volts noting the improvement both in color and efficiency.

Let me summarize in four propositions:

1. The interests and needs of the pupil should be the determining factor in the arrangement of courses and the choice of method.

2. It follows that a high degree of uniformity in teaching physics is neither practical nor desirable.

3. Wherever practicable, different courses should be provided for girls and boys.

4. Physics should be taught not as a preparation for college but as a preparation for life.

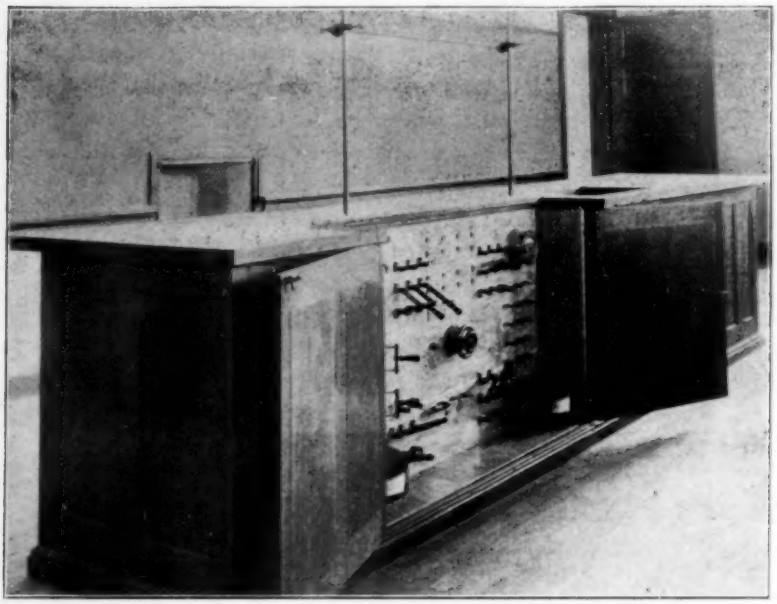
PHYSICS DEPARTMENT ELECTRIC SYSTEM.

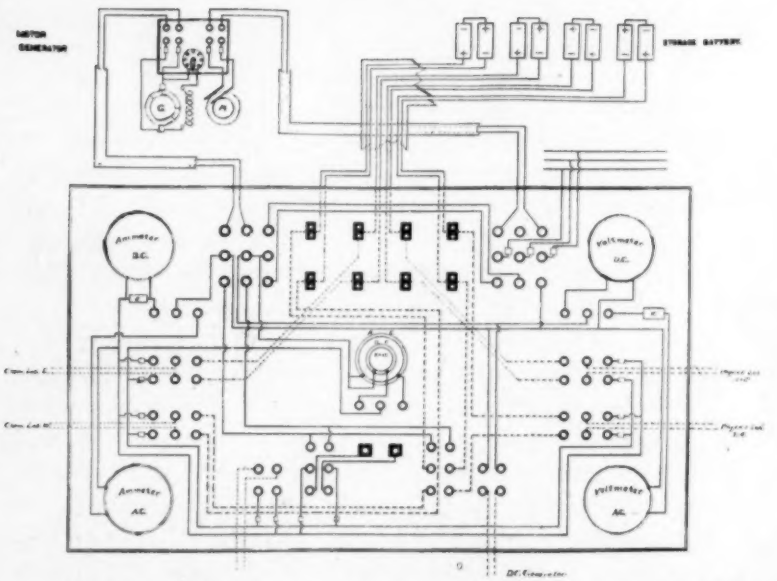
By H. C. Krenerick,

North Division High School of Milwaukee.

The accompanying print and drawing show the switch board and electric system of the physical science department of the new North Division High School of Milwaukee. The board is in the front part of the lecture table where by means of two doors it can be exposed to the view of the class or by removing the portion of table top directly above, the upper switches and storage battery terminals may be reached from the rear of the table. It is provided with direct and alternating current meters and rheostats. The alternating current rheostat is of sufficient size to control the 220-volt current for the opaque projector. The motor generator is stationed in the work room, a sufficient distance that no sound from the motor is heard in the lecture room.

I shall not take the space to explain in detail the various connections shown in the drawing. With but little study, anyone will find that the system is simple and not at all as complicated as it may at first appear. The switches controlling the circuits to chemical laboratory, physics laboratory, and terminals on board from which current will be taken for use on lecture table, are





connected in parallel to a main circuit on the switch board which can be fed by any of the following currents: From 25 to 45 volts direct current from motor generator; 110 volts direct current from generator in basement (not yet installed); either 110 or 220 volts alternating current from city mains; and any possible

combination from eight storage cells placed in the attic. By means of plug and cord connectors for the battery terminal receptacles (not shown in picture), any cell or combination of cells may be charged at one time or similarly the voltage may be tested at any time during discharge. The physics and chemical laboratory switches are each connected directly to a group of two storage cells so that, if desired, the laboratories may be supplied with current while the switchboard is being used for demonstration purposes in the lecture room.

THE CLASSIFICATION OF LABORATORY APPARATUS.

By A. T. Seymour,

Orange, New Jersey.

The following classification is based on the systems in use in a number of high schools and colleges. It is elastic and simple, adaptable to any laboratory, small or large. It is not necessary that the apparatus should be located in a single room. All that is necessary is that the apparatus should have a permanent location.

First, group the apparatus as well as possible by subjects. Physics will naturally be grouped under mechanics, heat, light, sound and electricity.

Chemistry apparatus may be grouped under the elements, potassium, sodium, silver, etc. When the apparatus has been thus located where it is to stay, each section should be numbered. It is best to place a number *over* the position of the apparatus. If there is a column of shelves one above the other, put a number at the top and then letter the shelves alphabetically from top to bottom. The numerals should be three fourths of an inch high and the letters should be half inch letters. These sizes are not too large to look well and may be seen across an ordinary room. When the numbering of the sections and the lettering of the shelves has been done, the position of each piece should be numbered. Thus if ten pieces of apparatus are on a single shelf, their places should be stamped from one to ten. In order to ensure the return of apparatus to its proper location after being used, each piece should be marked with its numbers and letter, the letter being placed in the middle and the shelf number last. Thus if a piece of apparatus stands on the fourth shelf from the top of

the second section and over a point marked five, it should be labeled 2D5.

This system should be applied to tools as well as other apparatus. Everything used in the laboratory should have its section number, its shelf letter and its place number.

For labels, Dennison's number and alphabet sheets may be obtained of a stationer. One number sheet will be sufficient for the sections but as many alphabet sheets must be obtained as there are sections. The shelf numbers may be stamped on with a rubber stencil outfit. A set of rubber stamps may be obtained for a dollar. The capital letters and figures should be three fourths inch and the small letters half inch. Such a set will be also useful for making charts for class use. A set of steel letter and figure punches will be found useful for marking wood and metal apparatus.

Glass is easily etched by means of hydrofluoric acid and a bottle (gutta percha) should be kept on hand for this purpose. The gas method of etching is slow and unsatisfactory.

Paper labels will not stick to varnished surfaces. To make the labels adhere it is necessary to first brush the surface with shellac varnish.

To attach labels to glass bottles, wet the label and attach to the bottle. Then brush over the label with a weak solution of gelatine in water. When the label is dry, brush it over with shellac varnish. The labels are thus made both acid proof and waterproof.

After the apparatus has been classified it should be catalogued. This will be found convenient for inventory, for reference and is useful where more than one person uses the apparatus.

A card index should be used. Boxes of various sizes are available. A neat box, holding a thousand cards will do for most laboratories. The guides should be labeled with the group titles. At the upper left hand corner of each card place the title of the apparatus. If for example there are six tangent galvanometers, write "Galvanometers, tangent." In the upper right hand corner place the section number, the shelf letter and the place number as indicated on the apparatus.

Beneath should be tabulated the name of the apparatus, cost, when purchased and where purchased and the number of pieces.

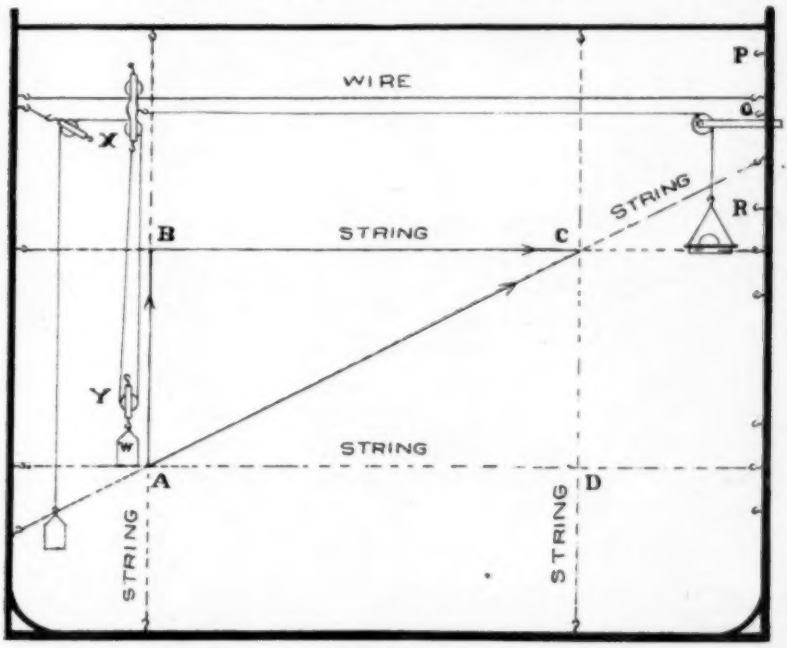
Apparatus thus classified will save the instructor many steps and much labor. Students who use the apparatus will not only know where to find the apparatus but also where to replace it.

The loss of apparatus can be easily detected, since a reference to the cards will show the number possessed by the school. The teacher will feel well repaid for the few hours spent in thus systematizing the apparatus.

COMPOSITION OF MOTIONS.

By B. L. Steele,
Marion High School, Marion, Ind.

The accompanying diagram represents an apparatus which I have used for several years to illustrate the composition of motions. It is easily set up, using clamps and steel rods. The ap-



paratus is arranged so that the weight, W, may be moved first from A to B and then from B to C (or first from A to D and then from D to C), or it may be moved in both directions at once, in which case it moves from A to C. By varying the combination of pulleys at *x* and *y* the relative magnitudes of the vertical and horizontal velocities may be varied, and by stretching the wire to P or R instead of Q the angle between the two directions may be made oblique. In any case the justification for the "triangle rule" or the "parallelogram rule" for finding the resultant velocity is readily seen.

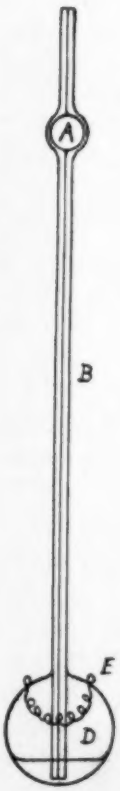
A USEFUL TYPE OF AIR THERMOMETER.

By E. J. Rendtorff,

Lake Forest Academy, Lake Forest, Ill.

I wish to present a form of air thermometer that I have found extremely useful in qualitative class demonstrations of some of the phenomena of heat, of light and of electricity. It has the virtue of being inexpensive, compact and universal in its uses, being adapted to either bench or projection purposes.

Most science teachers in secondary schools are given so little time to prepare experiments for class demonstration that the tendency is to neglect them, unless they are of such character that the apparatus can be assembled in class, with little loss of time. It is also frequently difficult to procure a sufficiently extended set of apparatus for this purpose and the average teacher is fortunate who manages to equip his regular laboratory with the apparatus needed for the fundamental work. It is therefore essential that the apparatus for class demonstration be universal in their application and not intended for one demonstration only. This property the air thermometer herein described most certainly possesses.



The apparatus consists of a bulb D, having a diameter of about 5 cm., to which is sealed a tube B, about 25 cm. long and of 1 mm. internal diameter, reaching almost to the bottom of the bulb. Near the top of the tube is a small bulb, A, to prevent an overflow of the colored liquid (kerosene) that partially fills D. A small coil, E, of Pt wire is sealed in the lower bulb and makes the use of the apparatus more extended, though it is not essential for all the demonstrations described below.

I will outline a few experiments in heat, light and electricity for which the apparatus is adapted. Many others will suggest themselves to every ingenious teacher.

1. Expansion of gases due to heat. Hold the bulb in the hand or over any source of heat.

2. Heat produced by friction. Rub the bulb vigorously with a rough rag, or shake Hg in a

bottle, transfer it to a beaker and immerse the bulb.

3. Cold by evaporation. Pour a few drops of ether, alcohol, or carbon bisulphide over the bulb.

4. Endothermic chemical reactions. Add ammonia water to crystals of iodine and immerse the bulb.

5. Exothermic chemical reactions. Immerse the bulb in a beaker of water and add concentrated sulphuric acid.

6. Freezing mixtures. Immerse the bulb in snow or chopped ice and afterward add salt.

7. Cooling by solution of a solid. Immerse the bulb in a beaker of water, add potassium nitrate and stir.

8. Heat produced by crystallization. Make a supersaturated solution of alum. When cool immerse the bulb and drop a small crystal of alum in the solution.

9. Cooling produced by the expansion of a gas. Place a rubber cork in the neck of a bell jar and push the top of the tube of the apparatus through the hole of the cork, so that it will have access to the air, while the bulb is in the bell jar. Place on an air pump receiver and rapidly exhaust the air.

10. Cooling produced by the compression of a gas. After the liquid has come to rest in the above experiment open the valve and allow air to enter the receiver.

11. Water containing ice remains at 0° C. until all the ice is melted. Place ice and water in a beaker, immerse the bulb and heat, while stirring constantly.

12. Convection currents in air. Hold the bulb above, below and on the sides of a hot solid.

13. Conducting power of gases. Place the bulb in a wide mouthed bottle, cork up the opening and immerse the whole in a larger vessel of hot water.

14. Conducting power of liquids. Completely immerse the bulb in a beaker of water. Pour a little ether on the water and ignite.

15. Reflection of radiant heat. Reflect the heat rays, emanating from a hot body, from a metallic mirror and place the bulb in the path of the rays.

16. Radiant heat varies inversely as the square of the distance. Place the bulb at different measured distances from a hot body and note the elevation of the liquid column.

17. Diathermancy and athermancy. Place tanks of alum dissolved in water and of iodine dissolved in carbon bisulphide

and also sheets of vulcanite, glass, metals, etc., between a source of heat and the bulb.

18. Selective absorption. Place the bulb at the focus of a pencil of light from a projection lantern. But little heating is produced as the rays that would be effective have already been absorbed by the lenses of the lantern and the intervening air. Focus the light on a piece of paper and it will burn. A thin sheet of platinum can thus be heated to redness.

19. Absorption of a blackened body. Blacken the bulb of the thermometer and repeat the above experiment. The thermometer responds at once.

20. Heating effect of various spectral colors. Hold various colored glass plates in a beam of sunlight or the path of the rays from a lantern. Hold the blackened bulb in the focus of the light.

21. Heating effect of the electric current. Run an electric current through the wire coil. Regulate the current and note that the heating effect varies as the square of the current.

22. Radiation from a blackened surface. Note how high a certain current will elevate the liquid column when the bulb is unblackened. Now blacken the bulb and run the same current through the coil. The column will be lower in the last case due to the more rapid radiation of the blackened surface.

23. Specific heat. Place the bulb in a beaker of water. Drop a hot solid into the beaker and read the thermometer. Repeat with other solids of the same weight and temperature as before, always using the same volume of water.

"Kentucky's Mountain Forests" is the general topic to which the September issue of *Arboriculture* is devoted. It is an excellent issue. Not only are natives trees figured and described, but most commendable results in modern forestry are presented. Kentucky is to be congratulated on the progress made in the decade or less in which the state has given serious attention to forestry.

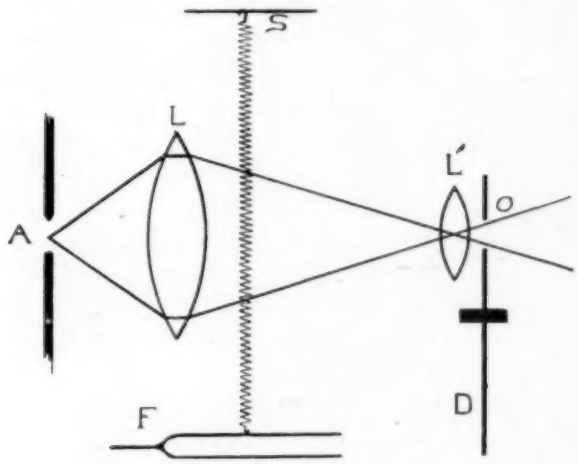
Teachers of botany who are interested in ferns—and presumably all real teachers of botany are—would do well to miss no numbers of Professor W. N. Clute's "The Fern Bulletin." Written by a most successful student and teacher of the subject, it always contains information and hints that must prove helpful to the readers. Presenting as it does "common knowledge" about ferns, it represents an excellent move toward making botany really accessible to the "common people."

A LECTURE EXPERIMENT IN LONGITUDINAL STATIONARY WAVES.

By H. M. Randell,

University of Michigan.

The arrangement of apparatus shown in the accompanying figure may be used very satisfactorily to illustrate stationary longitudinal waves. Before the condensing lens L of the lantern, the scheme of which is shown in the figure by the arc light



A, condensing lens L, and projecting lens L', there is mounted from a firm support S, a coil of spring brass wire No. 28, 1.3 cms. in diameter and about 70 turns long, the lower end being fastened to one of the prongs of an electrically driven tuning fork F, whose period is about 75 vibrations per second. If a fork is not available, a buzzer can be used, though it is not so satisfactory, as its rate of vibration is apt to vary.

The fork being set in vibration, that turn of the coil is found by trial which must be held in the clamp S to give the coil the proper length for producing stationary waves. This arrangement of spring and fork will result in three or four complete

segments of the stationary wave being in the field of the lantern and capable of projection upon the screen. The coil, as projected upon the screen by the focusing lens L′, will then show the turns at the nodes sharply, indicating little motion, and those in the neighborhood of the antinodes will be blurred, showing motion. To exhibit the phenomenon more in detail a light cardboard disk, mounted on the shaft of a motor, and provided with a single circular aperture, O, is rotated immediately before the focusing lens L′. The speed of rotation is adjusted by the use of a rheostat in the motor circuit or by the pressure of the fingers on the motor shaft till the stroboscopic effect is obtained. The separate turns of the coil as shown on the screen may then be made to move through their respective vibratory paths so slowly that the eye can follow their movements with ease. The turns of the coil at the nodes are seen practically stationary while the coils on either side move in opposite directions with amplitudes of vibration increasing in size till the antinodes are reached. In fact the statement commonly made of stationary waves in organ pipes, that the nodes are places of minimum motion and maximum change of density of the vibrating medium, while the antinodes are places of maximum motion and minimum change of density, is very clearly shown, as the turns at the nodes are alternately compressed and pulled apart, though suffering but small displacements, while the turns at the antinodes, though moving through the largest amplitudes, maintain approximately the same distance between the adjacent coils. Other points usually made in explaining stationary waves in air columns may be illustrated with equal success by this vibrating spring.

If the beam from the focusing lens L′ be made approximately a parallel beam and directed along a string vibrating as in Melde's experiment, the cord, being intermittently illuminated by the rotating disk may be made to apparently stand still and expose its configuration or to seem to move very slowly through its successive positions, by properly speeding the motor.

The experiments as above described are doubtless in use in many places but the fact that they illustrate so successfully a phenomenon rather difficult for beginners to get a clear idea of, and at the same time require only apparatus which is in nearly all schools, i. e., a lantern and a motor, made it seem worth while to show them at the recent Physical Conference of the Michigan Schoolmasters Club.

LABORATORY EQUIPMENT IN SECONDARY SCHOOLS.*

By T. Quincy Browne, Jr.,

Morristown School, Morristown, N. J.

There seem to be two reasons for undertaking this work, one practical, the other academic.

(a) The question is so often asked: "How much of a laboratory equipment should the secondary school have?" that it has become a matter of considerable importance to determine, if possible, the average equipment already in existence in this country, as a basis for the more theoretic considerations. In order to obtain this information, a very simple circular (a copy of which is attached) has been sent out to over seven hundred and fifty high schools in all sections of the country. The divisions made are not strictly geographical, but rather into sections, which, if the writer is not mistaken, represent groups with somewhat distinct developments. It has been the writer's good fortune to travel extensively over the United States, riding on horseback over a great deal of it in search of health. For the reasons named above, the country has been divided into the following sections:

1. New England: Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut.

2. Middle States: New York, New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia.

3. Southern States: Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Texas, Arkansas, Oklahoma, Indian Territory.

4. North Central: Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri.

5. Rocky Mountain: North Dakota, South Dakota, Nebraska, Kansas, Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Idaho.

6. Pacific: Washington, Oregon, California.

From the academic point of view a number of considerations suggest themselves. Twenty-five or thirty years ago, many edu-

*This article was prepared by the author in Teacher's College, Columbia University, under Professor John T. Woodhull as his Thesis for a master's degree. It is a preliminary report of some research being carried on by the department, which will be fully reported later.

cators expected to see science take her place alongside of Greek and mathematics; but to-day I think it will be pretty generally admitted that it has not done so. Of course, the classics and mathematics have been taught for so many centuries that they have a distinct advantage. Moreover, the limits of the scientific work best suited to the different grades have not yet been definitely determined. It is still an open question whether science should be introduced, in any form, in the grammar grades, and also where the line should be drawn between the high school and the college. There is still great divergence of opinion as to whether the teaching of physics and chemistry should be as far as possible mathematical or largely cultural.

As the statistics which follow will at most only furnish suggestions, from which possible inferences may be drawn as to the solution of the above questions, I will state now in a few words my own feeling on the subject, gained from a teaching experience of eight years. The reason why physics and chemistry have not succeeded in filling the place expected of them, I feel sure lies in the fact that educators have assumed that the new ideas would take consistent form in the mind of the youth without first bridging the gaps between the new concepts and those which his mind already contains. In other words, the approach to physics should be made through its simpler applications to everyday life. Moreover, it takes time to form new concepts, and James tells us that they must be developed by approaching the idea from a great many points of view, and by showing its relation to other concepts already formed. The French and the Germans both recognize these now fairly well established psychological and physiological facts, and spread their secondary school course over four or five years, instead of attempting to "cram" it all into a single year, as we for the most part still do in our secondary schools. The so-called "New Movement in Physics" seems to have grown out of a vague appreciation of these facts, and I trust it may do much to improve the teaching of physics in the secondary schools, and to define clearly the field which should be covered by the preparatory school and the college, respectively. In the schools, constant application of the principles of physics to everyday life, experiments which are for the most part qualitative, and some background of the history of the science, may do much to make it interesting and educative in the cultural sense. The colleges will then have a

better foundation upon which to rear the subject in a more truly scientific way, and the technical schools may develop it from the mathematical and practical standpoint.

The following table shows in concise form the average cost of laboratory equipment in physics and chemistry, and the annual cost of materials and new apparatus in two hundred and fourteen high schools situated in all parts of the country. The cost of laboratory equipment is intended to cover the expense of apparatus and movables, but not the fixtures, in the sense of those which are a part of the construction of the building. In a few cases the cost of an electric plant, largely if not entirely for demonstration purposes, has been included.

A study of the accompanying table shows that the representative high schools of the country are well equipped: the schools included nearly all number fifty, and by far the greater number have over a hundred pupils—a few over a thousand. The general average cost of physics is over $1,700.00, for chemistry, over $1,000.00; while those in the eastern and central portions of the country average over $2,000.00 for physics, and $1,142.00 for chemistry. The average for the schools in sixty-two of the largest cities of the country shows an equipment for physics of over $3,000, but for chemistry only $300.00 more than the general average. It has been asserted that while the schools are well equipped, the apparatus is not always kept in good condition, and added to year by year. From our tables, it is not possible to say with certainty whether the annual cost represents for the most part new material or repairs; but it is probably the former, because repairs are commonly made by teachers or employees. The Middle States and the Pacific show a good sized annual appropriation; while that of the larger cities, taken by themselves, is nearly $700 a year. This last may of course mean that the fine physical laboratories have received very considerable recent additions; and I am much inclined to think that this is the case, because by comparison with the annual cost of chemical laboratories, that for physics is very large. The very high cost per pupil in the physics classes in the larger schools shows that there the pupils must have the advantage of much more elaborate apparatus, but that this result is achieved only with a high per capita expense; in spite of the fact that these schools average nearly a thousand pupils each. In chemistry the annual cost per pupil is more or less the same in all the lists except that of the Pacific; though that of the Rocky Mountains and New

TABLE NO. 1

	Total No. of Schools	No. of Schools Rep't'g	Cost of Lab. Equipment (Phys.)	No. of Schools Rep't'g	Annual Exp. (Phys.)	No. of Schools Rep't'g	Cost of Lab. Equipment (Chem.)	No. of Schools Rep't'g	Annual Exp. (Chem.)	No. of Schools Rep't'g	Total No. of Pupils	No. of Schools Rep't'g	No. Taking Phys.	No. of Schools Rep't'g	No. Taking Chem.
1. New England	26	26	$ 39,149	25	$ 3,396	25	$ 19,200	25	$ 3,620	26	11,176	26	1,953	25	1,141
2. Middle States	43	43	75,157	43	9,092	36	35,519	36	4,678	43	24,433	43	4,491	35	2,423
3. Southern	22	21	32,110	20	2,775	20	13,960	20	2,235	22	8,085	22	952	21	848
4. North Central	93	91	175,022	92	14,558	82	104,594	83	10,875	92	55,727	93	8,162	83	4,807
5. Rocky Mt.	16	16	18,150	15	1,885	14	11,290	13	1,665	16	7,978	16	1,175	14	612
6. Pacific	14	12	26,300	13	2,865	12	13,200	13	2,490	14	7,498	14	1,109	14	640
	214	209	$365,888	208	$34,571	189	$197,763	190	$25,563	213	114,897	214	17,842	192	10,471
Av. per School			$1,750.66				$1,046.32				539		83		49
Av. per School					$166.20				$134.54						
Av. per Pupil					1.98				2.47						

Av. per School (taking only the 192 which have Chemistry: i. e., leaving out those with no Chemistry classes) 54

TABLE NO. 2

	No. of Schools	Av. of Physics Equip't	Av. of Annual Exp.	Annual Cost per Pupil	Chemical Equipment	Annual Cost Chemistry	Annual Cost per Pupil	Av. No. in School	Av. No. Phys.	Av. No. Chem.	Av. No. per School offering Chem.	Schools with no Chem.
1. New England	34	$1,672.03	$137.30	$1.73	$ 739.40	$144.70	$3.10	450	80	46	47	3%
2. Middle States	43	1,747.88	211.44	2.03	986.63	130.00	1.86	568	104	56	70	19%
3. Southern States	22	1,529.00	138.75	3.23	698.00	111.75	2.79	367	43	40	40	4½%
4. North Central	93	1,923.32	158.24	1.80	1,275.54	131.03	2.27	606	88	52	58	10³⁸%
5. Rocky Mt. and the Plains	16	1,134.37	125.00	1.71	806.43	128.07	3.40	499	73-2	38	44	12-2%
6. Pacific	14	2,192.00	220.00	2.79	1,100.00	191.54	4.16	536	79	46	46	0%
Total	214	$1,750.66	$166.20	$1.98	$1,046.32	$134.54	$2.47	539-2	83-2	49	54-2	10³%
Schools of Cities of over 100,000 Inhabitants	62	$3,193.53	$690.15	$4.25	$1,327.27	$234.30	$2.37	990-5	163	99	99	0%
New England, Middle and North Central	108	2,086.53	186.20	1.73	1,142.00	165.50	2.43	626	98	62	68	1%

Percentage taking Physics = 15.4 (In all U. S.)
Percentage taking Chemistry = 91 " " "
Percentage in Eastern and Central States taking Physics = 15.65
Percentage in Eastern and Central States taking Chemistry = 9.9

England shows a larger expenditure than the rest of the country. This may be partly due to the fact that, compared with the Middle States, New England and the Pacific show a greater proportion of students taking chemistry; and this in turn may indicate a greater interest in the subject in these sections; though I feel very doubtful of this inference. I think that the fact that the averages of the total numbers in the schools of the various sections are so near the general average shows that the table may be considered fairly representative. The Southern average is small, but the schools in that section are also, as a rule, small. The average in the North Central division is particularly large; and this, too, I think, accords with the general conditions there. In some regions, where the various settlements may in themselves be small, the high school is located at a central point, where it is accessible from several settlements. These are called township high schools, and seem to be common in the prairie states. No doubt, good rapid transit facilities have made this arrangement feasible.

As it seemed wise to ascertain for chemistry, both the average number taking chemistry per school, and the average number taking chemistry in a section, columns have been made for both these figures. All the schools reporting have physics; and, in some of them, this subject is required for graduation. Of the two hundred and fourteen schools reporting, twenty-two have no chemistry; and a few of the smaller schools, while they teach chemistry, have no laboratory equipment. Only three, however, made such a report, and they all expressed the hope of soon having better facilities. One school of 377 pupils reported twenty in laboratory physics, thirty studying physics without the use of a laboratory. Only one school reported no chemistry and no physics, and that was a school of 120 pupils in West Virginia, which stated that, owing to the rapid growth of the town, laboratory facilities had not been provided; but that there was a private school in the town which had these. A good many schools have more pupils in chemistry classes than physics, but they seem to be pretty equally distributed between the larger and the middle sized schools, and there seems to be no significant reason for these facts; while the technical high schools and manual training high schools have a good deal of physics, there are, so far as I know, in this country no trade schools, such as they have abroad, where chemistry might be taught in order to educate expert workmen.

In the total number of schools tabulated, the percentage of pupils taking physics is 15.4; chemistry, 9. In the Eastern and Central States, the percentage is very nearly the same. In considering these figures, it must be borne in mind that, as physics and chemistry are one year courses in most high schools, it is quite evident that the actual percentage of those who take these courses is considerably above the figure given; because this fifteen per cent represents only the number of scholars taking physics in a single year; while at least half of the pupils stay in the high school two years, and many of them four; so that an individual, for instance, might be counted four times in the school total, and only once in the physics total. If this were the case with all scholars, the true average for physics would be four times 15, or 60, and for chemistry four times 9 or 36. I should judge that the actual figure must be between 25 and 30, i. e., that about 25 to 30% of all the boys and girls who enter the high schools take physics, and that about 15 to 20% take chemistry.

There seem to be considerably more girls than boys on the average in the high schools, but as far as I can judge they take the sciences in about equal proportions. Many high schools now have several electives in the science courses, so that those who do not take chemistry or physics as a rule have taken either botany, physiology, or geology. In fact, at least one science is frequently prescribed. It should be added, by way of general remark, that many, probably most, of the statistics of cost and expense given are estimated, but in a total of two hundred and fourteen it is most likely that the discrepancies one way and the other from actual values would nearly equalize each other. But in spite of this fact, I think that the cost of apparatus is probably overestimated, because in all probability insufficient allowance has been made for depreciation and for apparatus that is out of repair. Then, too, the change of teachers from year to year probably means that certain pieces of apparatus are either discarded or left unused. On the other hand, it is quite possible that many instructors make with their own hands valuable pieces of apparatus. Furthermore, it is certainly true that the educational value of experiments is not by any means to be always gauged by the cost of apparatus, but by the skill of the operator, and his ingenuity in devising simple mechanism, which will show plainly the phenomena he wishes to demonstrate.

Such subtleties of course no figures can penetrate; yet I presume it is safe to assume that averages of this kind have a distinct value. They certainly show the general trend of things and in this case demonstrate clearly that the large cities have been very active of late in putting up fine buildings with excellent laboratories and that the substantial towns seem to be not far behind in this respect; and it is astonishing that even the smaller schools in many places seem to be well equipped. On the other hand, there are surprising exceptions; but these exceptions, I think, in the large, only serve to prove the rule.

In any comparison between the sciences and the classics or mathematics, it must be borne in mind that the first mentioned is always at a disadvantage, because of the necessity of a special equipment, which must be more or less expensive; and because of the wear and tear on apparatus and the actual use of material by the student.

In any discussion of the question how far laboratory methods have been introduced into secondary schools, I think the foregoing figures help to prove that there is a widespread and growing tendency to have the pupil use his own hands and eyes and to a certain extent test principles and laws for his own satisfaction and edification; thus learning by direct use of his senses what it would take him far longer to comprehend even in a hazy way from the printed page alone.

How far laboratory methods have justified themselves is a very difficult matter to decide with certainty, but it must be the conviction of all who have had experience in the matter, that, in the cases where these methods have failed to justify their use the fault lies rather with the teacher than with the methods.

With the September issue of the magazine heretofore known as *Forestry and Irrigation*, it changes its title to *Conservation*. Below this new title appears the legend, "Woods and Waters, Soils and Ores," which presumably is further intended to indicate the scope of the magazine in its new form. The appearance of a magazine devoted to conservatism of the natural resources of the country is timely. The great stimulus recently given to this topic should result in turning the attention of many magazines to this question. The assumption of the title "Conservation" will not deter other magazines from presenting much valuable material relating to the general question of consideration.

THE SYMPOSIUM ON THE TEACHING OF BIOLOGY.

The following is a continuation of the symposium on the teaching of biology which began in the last issue of this magazine. The letters that have been received by the editors indicate considerable interest in the discussions. It is desired that all who have something to contribute to the discussion do so, but the discussions should be brief and pointed, and should be forwarded to the department editors as early as possible. In the December issue the symposium on physics will begin and it will prove interesting and profitable for those interested in botany and zoölogy to note the points of view of those who discuss the problems in the teaching of the physical sciences.

O. W. C.

THE COURSE IN GENERAL BIOLOGY.

JOHN M. COULTER,

Illinois State Normal School.

Perhaps this is not the time for one who is only a university man to venture any opinion about high schools, but some of us have held on to an intense interest in these schools, an interest which centers in the pupils rather than in the subjects.

I have noted the rising tide of published opinion in favor of a course in general biology for high schools, as opposed to the separation of botany and zoölogy as distinct subjects. This is a reversion to a primitive stage of biological teaching both in schools and colleges. The method was tried faithfully, but not successfully; at least a general change to botany and zoölogy followed. It may be that the new generation can make general biology more effective in the schools than did their predecessors, but it may be useful to recall the prominent reasons for abandoning the scheme.

It was found that so far as familiarity with material was concerned, a teacher was always either a botanist or a zoölogist, and it was felt that familiarity with the material should be the first prerequisite for teaching. It so happened that zoölogists often assumed knowledge of botanical material; and all the "general biologists" turned out to be zoölogists in disguise. As a consequence, under such a scheme plants stood for little or nothing.

It was also found that all of the general biological principles could be developed by using either plants or animals as illustrative material. It was felt that the details of information about plants and animals should be subordinated to the larger conceptions; and it was found that with mixed material these larger conceptions were impossible.

It was also soon found that the very largest conception in reference to organisms is their evolution; and to develop a mental picture of the evolution of a great kingdom was only possible by following structures that showed some continuity. This certainly meant the following of plants clear through, and of animals clear through, from the simplest to the most complex. This picture can be made very vivid, and it banishes details to their proper limbo. The separate treatment of plants and of animals, therefore, resulted in clear and large conceptions. Experience proved that a mixture of plants with animals resulted in a clutter of details and no conception of continuity.

It was for such reasons that general biology was abandoned, and they seemed to justify the change. The change was made in the interest of the pupils, because it was felt that a few large views were more important for the vast majority of pupils who would have no more formal contact with biology, than a confused mass of details which they would have no opportunity to clarify.

The historical sequence in methods, so far as botany is concerned, has been as follows: (1) the period of plant "analysis," (2) the period of general biology, (3) the period of botany and zoölogy. The schools of the Middle West are generally in the third period; while the Eastern schools are just emerging from the first period, and to them general biology seems to be the next step in advance. The distinguished president of a vigorous Western state university has announced that the Western schools have now advanced so far in biological instruction that "the university is quarantining against general biology."

It is estimated by leading mining experts at Johannesburg that the amount of gold still to be mined along the Rand reef is valued at $5,000,000,000.

The first appearance of glass was probably in Egypt. The Phœnicians were the first skilled in the making of a very transparent variety, however.

GENERAL BIOLOGY VS. BOTANY, ZOOLOGY AND HUMAN PHYSIOLOGY.

By G. M. Holferty,

Central High School, St. Louis, Mo.

More than a decade ago some of the state universities abandoned one-year courses in general biology, substituting therefor separate half-year courses in botany and zoölogy. This was by no means a step backward, for the separate branches of biology (botany and zoölogy) at that time were in quite a different phase or stage of development from that in which they were at the time of the birth and organization of the science of biology. In most American schools at least botany was in the analysis or plant-naming stage following Linnæus and Gray. Whatever work was done on the flower was for the purpose of classification and not as a study of this organ as a seed-producing mechanism. The work was taxonomic. Zoölogy was in a natural history stage dealing with external characters and habits, leading likewise to classification (Tenney, Orton, etc.). The two branches were separate kingdoms. Differences and not similarities and identities were constantly advanced and given prominence. The general biology texts and teaching of the seventies and eighties changed all this to a minimizing of differences and a harmonizing of similarities and identities. In this stage the great principles of biology were made prominent and efforts made to illustrate and verify evolution by a study of types. The method seems logical—why then abandon it? Manifestly because it was not bringing about the results anticipated. For it was found that while correllation and evolution (ultimate desiderata) were comprehensible by the student having a grasp of the facts and data of the new or modern botany and zoölogy, the rapid passing from plant to animal, and animal to plant while accumulating the necessary facts and data about plants and animals and at the same time trying to hold in mind the great biological principles and the evolution and development of complex organs and systems proved confusing to many beginners in biology. Besides, when the student did attempt to follow the evolution or development of an organ or system he kept the continuity by reference to types lying totally within one field or the other regardless of an alternation of plant and animal types in his study of general biology.

If then separate half years in botany and zoölogy have been recommended instead of one-year courses in general biology for university students, how much greater is the need for this separation in the high school? Further, if the men who tried this method at a time when general biology was regarded as composed of two branches (botany and zoölogy) found separation advisable, how much greater is the need for separation if a third branch (human physiology) is to be regarded as a part of general biology?

While it is well to regard human physiology as a biological study, it seems out of harmony to regard it as a branch of biology and put it in the high school course as an integral part of general biology and thus reduce the time devoted to it and likewise that devoted to botany and zoölogy. Every teacher of science should stand firm for one half year as a minimum for any science which finds a place in the high school curriculum. Let us not fall back to three months or even a "fourteen weeks" period for any science. It is about as hard to reach the heights in biology without the struggle in "declensions and conjugations" as it is in language and literature.

A LETTER CONCERNING THE BIOLOGY SYMPOSIUM.

A teacher of botany in one of the largest Central Western high schools, upon reading the biological symposium, immediately wrote the following letter to the botanical editor of SCHOOL SCIENCE AND MATHEMATICS. The editor at once wrote and secured permission to publish the letter.

DEAR DR. CALDWELL:

When the lion cub asked his mother why all pictures of combats between men and lions represented the men overcoming the lions, his mother replied that it was because all the pictures were painted by the men. I am reminded of this by that Symposium in SCHOOL SCIENCE AND MATHEMATICS. How can anyone expect anything but praise for a hodge-podge of botany, zoölogy, and physiology from teachers in a State like New York with its antiquated system of a course of biology that is given in the first year of the High School?

The statement that a year's work in all of four sciences is all that is desirable for High School pupils of the present day, sounds like a wail from the Middle Ages. Where is it written that this is all a pupil needs for life? Which is better for him if he cannot have both; a knowledge, say, of algae or a knowledge of the "Ancient Mariner" and "Ivanhoe"? Of the nervous system of the earthworm or a smattering of Greek and Spanish? I am not specially fond of earthworms or algae, but I believe the study of such things to be more useful to the average child than the others I have named. I am willing to admit that in special cases the latter may be most useful, but as

High School courses are at present constructed and administered, the average child gets too little of science, rather than too much.

Usually the schools that can spare only a half year each for zoölogy and botany, that is, a year of "biology," offer several years of language, often including French, German, Latin, Greek, and Spanish. The pupils also usually spend several years on "Literature"—usually a dilute college course in the study of various works of fiction—without knowing what it is all about, and after all their "language" study can seldom either speak or read in any one with accuracy. It would be far better, it seems to me, if the same amount of time were spent in studies such as botany and zoölogy that would open the eyes, develop the judgment, quicken the perceptions, and stimulate an interest in the world in which we live. Shall we go on studying languages and literature as at present, believing in witches, ghosts, charms, luck, signs, divination, dreams, and all the rest; shall we continue swallowing patent medicines, avoiding "night air," neglecting ventilation, drinking impure water, and considering all diseases as visitations of Providence, or shall we study the sciences of a scientific age and become enlightened enough to be sensible? To which do we owe the most, the "humanities" (language and literature), or the divinities (the physical and natural sciences)?

It seems to me the tenor of several papers in the Symposium is that we have gone too far in science and should begin to "crawfish." I do not know a really good school that does not offer year's course in either or both botany and zoölogy, and it strikes me that they should hold their position and invite the others to get in line as fast as possible.

To the statement that it is not necessary that we "finish" botany and zoölogy in the High School it may be said that the term "finish" is only comparative. I am free to say that in a half-year devoted to either botany or zoölogy the subject cannot be finished in any such sense as that term applies to the finishing of algebra and geometry. There is not the fullest value in teaching any science unless all the fundamental principles can be taught with sufficient illustration to make them of significance to the pupil. That botany and zoölogy can be so taught in less than a year, few will be so unwise as to affirm. And yet we give a year each to algebra and geometry. If a choice must be made, there is better reason for giving less time to algebra and geometry than to the natural sciences. After leaving school the average child never uses his algebra and geometry, as such, while he has need of his zoölogy, his botany, his physiology, and his physiography practically every day of his life. I value geometry and algebra too highly seriously to suggest their giving way to biology, but I think the comparison will hold. I dare say that much of the protest against the established order of things educational which finds expression in manual training, domestic science, nature-study, etc., is due to the fact that the studies at present offered do not fit our boys and girls for real life. Let us not add to their obfuscation by sending them out into the world with but a glimpse of the planet upon which all their days must be spent.

If you have had the patience to read down this far, let me add that this is written mainly to relieve my mind. I am a bit inclined to stand up for a lot of botany and zoölogy even if you cannot eat 'em or earn your living by them as soon as you get out of school. I have seen so much of park commissioners and of the general public with no perception of scenic beauty, of parsimonious officials blind to the nature interests of their constituents, that, like Nero, I almost wish the public had but one head—and that I could stuff it full of natural science.

C. N. W.

FACTORS THAT MAKE FOR SUCCESS IN THE TEACHING OF BIOLOGY IN OUR HIGH SCHOOLS.[1]

By H. H. Whetzel,

Cornell University.

When in reply to the kind invitation of your chairman to speak to you on this occasion, I replied that I would attempt to outline what appeared to me to be the factors that made for success in the teaching of biology in our high schools, I felt that it would be an easy matter for me to make concrete and to classify my ideas on the subject. The task has proven to be not without difficulties. While the four characteristics that I shall briefly discuss are not to be considered the only ones that figure in successful biology teaching, they appear to me to be among those of first importance.

Since our ideas and opinions on such a subject are very largely determined by our experiences, I have kept before my mind in the preparation of this paper a few good teachers of biology that I have been so fortunate as to know well. Not all of them are high scool teachers, but I feel sure that those of them that teach in college or university would be equally successful in teaching in high schools. We should remember that the college freshman is only a high school senior three months later.

With possibly that one exception that proves the rule, I find that every one of these teachers is thoroughly and broadly trained in the subject-matter of biology. They know the subject-matter. They are able to view the whole field and distinguish the great factors in life phenomena. They have clear conceptions of the structure, physiology and evolution of living things. They appreciate keenly the interrelations of plants and animals. They bristle with suggestions of related things. They see the plant

[1] Read at the December, 1907, meeting of the New York State Science Teachers' Association

not merely as a composite of root, stem, leaf and flower, a thing to be analyzed and named, to be pressed and mounted on a herbarium sheet, but a vitaly living organism, thrusting its roots into the soil, seeking and absorbing food and water therefrom, spreading its broad green leaves to the sun and air that carbon may be gathered for the manufacture of starch, and that elaborate foods may be made for the use of the living protoplasm of each active cell. It unfolds is blossoms to the insect world that pollination may be affected, fertilization accomplished and its posterity assured. To know plants and animals in relation to their environment, and to each other, to see them meet and solve the problems of their existence and perpetuation, to understand something of the history of their evolution, this is to know the subject-matter of biology.

I recall also that all these teachers (and here there is no exception), are enthusiastic. They glow with enthusiasm born of knowledge and it is abiding and contagious. Enthusiasm on the part of the teacher begets interest on the part of the student. The teacher for whom every living thing has a message, to whom every living thing presents problems to be solved, cannot fail to arouse interest and enthusiasm in pupils. As my own biology teacher used to say, such teachers have the "divine touch." Of none could this be more truly said than of him. A half hour's talk with him would fire me with enthusiasm and energy for weeks of hard work. It does still when I have the good fortune to be with him for a visit. To his inspiration more than to anything else do I attribute my interest and ambition along biological lines. The man who lacks enthusiasm, be he ever so wise, cannot teach. His enthusiasm must be broad, it must not be special. The whole field and its problems must be vital to the teacher of biology. Therefore his enthusiasm must be readily and quickly transferred. The problem in hand to-day, the plant just found, the animal just captured, must be the thing of vital importance and interest and it must present problems and possibilities.

Another common characteristic of these teachers is that they are hard workers. Every teacher knows that the lesson that receives the most preparation and study by the teacher is the best taught. The interest and enthusiasm of the pupil are directly proportional to the amount of work put upon the subject by the teacher. If you don't believe this, try it. I well remember the amazement with which I learned that my biology teacher spent

three hours in the preparation of every lecture that he gave us, though he had taught the subject for at least ten years. My amazement continues to this day, but it is now that he should have been able to have given such wonderful lectures with so little preparation. Hard work on the part of the teacher is, if properly directed, sure to result in hard work and interest on the part of the pupil. The lazy teacher should never expect pupils to work.

These teachers of mine are all keen observers. They see the great problems of living things in the plants and animals around them. The weeds beside the path, the stagnant pond, the miry marsh, or thorny thicket, teem with life and so with interest. What a revelation and inspiration was my first field trip with the teacher who could really see things. I had gone over the same grounds many times before, but I had never seen half the things we found that day. I have since learned that much of the secret of finding living things is in knowing what you are looking for, but more in knowing the related environment, in other words, in knowing the organism, in knowing it at home. But not only must the teacher be keenly observant himself, he must be able to open the eyes of his pupils.

And finally the ability to teach common things seems to be a characteristic of all these teachers that I have in mind. They at once related me to my environment. A jar of pond water from a nearby creek brought the first message of cell life, its structure, its physiology, its evolution. Pith from the elder bush I had known all my life, a potato from the patch I had so often hoed, a twig from the basswood tree by the laboratory door, gave me my first insight into the wonders of cell structures, tissues, their specializations and adaptations, the division of labor and development of plant organs, etc. Life with all its problems of origin and evolution was at my door. I had only to reach out to touch and handle it, examine and delve into its mysteries. The problems were mine for the asking, their solution mine for the trying. For finding out is fun, and work is living.

Small proportions of sulphuretted hydrogen (H_2S) are dangerous to life. Even 0.1% will cause death in an hour. When dangerous proportions are approached the characteristic smell disappears.

The February (1908) gold output of the Rand has been estimated at 550,000 fine ounces, which compares with 560,329 fine ounces in January, and 493,542 fine ounces for the corresponding month of 1907.

THE EDUCATIONAL USES OF SHARKS AND RAYS, ESPECIALLY THE ACANTH (Squalus acanthias or "horned dog-fish").

By Burt G. Wilder,
Cornell University.

Abstract.*

Half a century ago students of Vertebrate Zoölogy and Comparative Anatomy dissected the human body and such animals as chance provided. During the last thirty years there has been recognized the desirability of selecting certain so-called types or representatives of the several groups to be dissetcd in accordance with directions. The choice of forms has varied greatly with localities, instructors and periods. Theoretic appropriateness and practical availability have sometimes conflicted.

As the outcome of forty years of experience and reflection, and with increasing conviction as to the supreme importance of the early acquisition of some real knowledge of the brain, I submit the following proposition:

For the study of the structure, development, succession and relationships of vertebrates the best group to begin with is the Selachians, the sharks and rays; if several forms can be studied the first should be, and if but one, that one should be the acanth or "horned dog-fish," *Squalus acanthias.*

Besides its purely zoölogic uses the acanth may facilitate the solution of an educational and moral problem the importance and difficulty of which is rapidly being recognized by parents, teachers and sociologists. The following is based on my rough notes of a lecture by Prof. Louis Agassiz, in November, 1867: "Unlike most of the lower Vertebrates, with many kinds of sharks and rays the young are developed within the mother and the two sexes are easily distinguished by outward form. With the male the inner margins of the pelvic fins are prolonged and modified so as to constitute organs by means of which, while facing the female, the seminal liquid is introduced and internal impregnation is accomplished. These fishes were among the earliest Vertebrates, yet their sexual relations were prophetic of conditions among the higher classes, among the Mammals, and even with the other extreme of the series, the human species."

*Witness an article in The Nature Study Review for November, 1907, editorials in the Ladies' Home Journal, especially for January, 1908, and the publications of the American Society for Sanitary and Moral Prophylaxis.

PROBLEM DEPARTMENT.

IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

113. *Proposed by Calvin M. Woodward, Dean of School of Engineering and Architecture, Washington University, St. Louis, Mo.*

A merchant gave four workmen a pile of oranges to be divided at the close of the day. A finished first and went alone to get his share. He counted the pile and found that if he gave one to a monkey chained hard by, the remainder would be divisible by four. So he gave one to the monkey, took his fourth and went home. Next B came, and thinking himself the first, he too counted the pile, gave one to Jocko, took his fourth and went home. Later C, and at last D, came and each did exactly the same thing. Next morning the men met and on comparing notes, agreed that there must be a pile left. So they went together to the orange room and counted the pile. They then found, as each had found before, that if one were given to the monkey, as hungry as ever, that the remainder would be exactly divisible by four. So the monkey got his fifth orange and the last pile was divided. How many oranges were in the original pile?

(If desired, the problem may be made general by having n men, and after each counting giving the monkey a oranges.)

I. Solution by I. L. Winckler, Cleveland, Ohio.

Let x = the number of oranges, n = the number of men. Then

$\frac{(n-1)(x-a)}{n}$ = number left after first took nth part, and

$\frac{(n-1)^2(x-a) - an(n-1)}{n^2}$ = number left after second took nth part of remainder. In general:

$\frac{(n-1)^n(x-a) - an(n-1)^{n-1} - an^2(n-1)^{n-2} - \ldots\ldots an^{n-1}(n-1)}{n^n}$

= the number left after the nth man had taken the nth part of the remainder.

$\therefore \frac{(n-1)^n(x-a) - an(n-1)^{n-1} - an^2(n-1)^{n-2} - \ldots\ldots an^{n-1}(n-1) - an^n}{n^{n+1}}$

= an integer. The terms of the numerator after the first are in geometrical progression, hence $\frac{(n-1)^n(x-a) - an[n^n - (n-1)^n]}{n^{n+1}}$ = an integer. Therefore

$\frac{(n-1)^n(x-a)}{n^{n+1}} - a + \frac{an(n-1)^n}{n^{n+1}}$ or, $\frac{(n-1)^n}{n^{n+1}}(x - a + an)$ = an integer $= p$.

From this $x = \frac{pn^{n+1} - a(n-1)^{n+1}}{(n-1)^n}$ = an integer.

If $p = (n-1)^n$ then x is integral, therefore $x = n^{n+1} - a(n-1)$. In particular, if $n = 4$ and $a = 1$ then $x = 1021$, the solution for the problem as stated.

II. Solution by Eugene R. Smith, Montclair, N. J., and T. F. Leighton, Chicago, Ill.

Let x be the number each received at the last division, then $4x + 1$ were in the pile before division. Before the fourth man divided them there were $\frac{4}{3}(4x + 1) + 1$ or $\frac{16x + 7}{3}$. Similarly, before the former divisions there were $(64x + 37)/9$, $(256x + 175)/27$, $(1024x + 781)/81$. This last number reduces to $12x + 9 + 52(x + 1)/81$. Since this must be an integer, $\frac{52(x+1)}{81}$ must be integral, and $x + 1 = 81$ or $x = 80$. Substituting this value, we easily find the total number of oranges to have been 1021.

There are of course other answers to be obtained by using $x + 1 = 162$, etc.

Geometry.

114. *Proposed by C. S. Cory, Cedar Falls, Iowa.*

Draw a circle that shall pass through a given point and touch two given unequal circles.

I. Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.

Let A be the given point; O, O′ the given circles. Draw OO′ the line joining the centers of the given circles, and let the common tangent KH to O and O′ intersect it in P; join PA and make $PA \cdot PB = PK \cdot PH$. Now a circle through A and B, tangent to O or O′ satisfies the required conditions.* Both external tangents, and both internal tangents may be used.

II. Solution by T. M. Blakslee, Ph.D., Ames, Iowa.

This is Corollary 2, page 122 in Casey's "Sequel to Euclid"; the proposition being: "To describe a circle touching three given circles." To solve the problem Casey says: "Describe the orthogonal circle of X, Y, Z (the given circles) and draw the three chords of intersection of this circle with X, Y, Z respectively; and from the points where these chords meet the axis of similitude of X, Y, Z draw pairs of tangents to Z, Y, Z; then the two circles described through these six points of contact will be tangent to X, Y, Z."

115. *Proposed by William B. Borgers, Quincy, Ill.*

In several Geometries (for example, in Wells' Solid Geometry, page 251, Ex. 5) the question is asked, "What is the locus of points in space equally distant from a given plane?" Discuss the question: Is this a definite problem?

Solution by the proposer.

In any ordinary sense there is no such locus. There is a locus of points at a given distance from the plane—viz., two planes parallel to the plane, and at the given distance from it. But all other points in

*To draw a circle through two given points A and B tangent to a circle O: through A and B draw a circle intersecting O in C and D. Let the lines AB, CD meet in E. From E draw a line EF tangent to O at the point F; now ABF is the required circle.—*Ed.*

space would satisfy the condition, by taking different distances, and as the problem says nothing about a given distance, we have no right to assume it means *one* given distance.

Trigonometry.

116. *Proposed by Mrs. Harold Blair, Mt. Clemens, Michigan.*

Show that $\sin(\lambda'' - \lambda') - \sin(\lambda'' - \lambda) + \sin(\lambda' - \lambda)$ may be reduced to $4\sin\frac{1}{2}(\lambda' - \lambda)\sin\frac{1}{2}(\lambda'' - \lambda')\sin\frac{1}{2}(\lambda'' - \lambda)$. (From Crockett's Trigonometry.)

I. Solution by W. L. Malone, Fern Hill, Wash.

The given expression evidently equals $2\sin\frac{\lambda''-\lambda'}{2}\cos\frac{\lambda''-\lambda'}{2} + 2\cos\left(\frac{\lambda'+\lambda''}{2} - \lambda\right)\sin\frac{\lambda''-\lambda'}{2} = 2\sin\frac{\lambda''-\lambda'}{2}\left[\cos\frac{\lambda''-\lambda'}{2} - \cos\left(\frac{\lambda'+\lambda''}{2} - \lambda\right)\right] =$

$2\sin\frac{\lambda''-\lambda'}{2}\left[2\sin\frac{\lambda''-\lambda}{2}\sin\frac{\lambda'-\lambda}{2}\right] = 4\sin\tfrac{1}{2}(\lambda''-\lambda')\sin\tfrac{1}{2}(\lambda''-\lambda)\sin\tfrac{1}{2}(\lambda'-\lambda).$

II. Solution by T. M. Blakslee, Ph.D., Ames, Iowa.

This is the same as $\sin(\lambda'' - \lambda') + \sin(\lambda - \lambda'') + \sin(\lambda' - \lambda)$ and the latter is a special case of $\sin A + \sin B + \sin C$ where $A + B + C = 0$., $C = \lambda - \lambda''$.

In proof, $C = -(A+B)$, $\sin C = -(\sin A\cos B + \cos A\sin B)$.

$\sin A + \sin B + \sin C = \sin A(1 - \cos B) + \sin B(1 - \cos A) = 2\sin\frac{1}{2}A\cos\frac{1}{2}A\cdot 2\sin^2\frac{1}{2}B + 2\sin\frac{1}{2}B\cos\frac{1}{2}B\cdot 2\sin^2\frac{1}{2}A = 4\sin\frac{1}{2}A\sin\frac{1}{2}B(\sin\frac{1}{2}B\cos\frac{1}{2}A + \sin\frac{1}{2}A\cos\frac{1}{2}B) = 4\sin\frac{1}{2}A\sin\frac{1}{2}B\sin\frac{1}{2}(A + B) = -4\sin\frac{1}{2}A\sin\frac{1}{2}B\sin\frac{1}{2}C.$

Applied Mathematics.

A squirt gun has a hole $\frac{3}{32}$ of an inch in diameter. It is held vertically upwards and a pressure of 50 pounds is applied to the piston which is $\frac{7}{8}$ of an inch in diameter. Neglecting all resistance, (a) how high will the water rise? (b) if held horizontally ten feet from the ground what will be its range?

Solution by I. L. Winckler, Cleveland, Ohio.

I. Let h = height in feet of a column of water that will produce pressure of 50 lb. on a surface $\frac{7}{8}$ inch in diameter. Then the volume of the column is:

$$v = \frac{22}{7}\times\frac{249}{256}\times\frac{12}{1728}\text{ h cu. ft. and the weight in lbs } 62\tfrac{1}{2}v = 50.$$

Therefore $h = 191.5$ ft. = height to which water will rise.

II.* From $s = \frac{1}{2}gt^2$, where $s = 10$ and $g = 32.2$ we get $t = .7881$ seconds. Also from $v = 8.025\sqrt{h}$ we get $v = 111.053$ ft. The horizontal range is therefore $111.98 \times .788 = 87.522$ ft.

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*Let α = angle of elevation; v = velocity of projection; h = height for the velocity v under gravity; x and y the coordinates of the projectile (origin at point of projection), then

$$y = x\tan\alpha - \frac{gx^2}{2v^2\cos^2\alpha} = x\tan\alpha - \frac{x^2}{4h\cos^2\alpha}.$$

But here $\alpha = 0$, $y = -1$, therefore $x = 87.552$.—*Ed.*

CREDIT FOR SOLUTIONS RECEIVED.

Trigonometry 71. J. J. Browne (1).

Algebra 106. M. Jordan (1).

Geometry 107. Nelle W. Reese (1).

Algebra 113. T. M. Blakslee, W. T. Brewer, Egbert A. Case, A. M. Harding, T. F. Leighton, W. L. Malone, H. E. Trefethen (3 solutions), Eugene R. Smith, I. L. Winckler, G. B. M. Zerr. (12).

Geometry 114. T. M. Blakslee, H. E. Trefethen (2 solutions), Eugene R. Smith, I. L. Winckler, G. B. M. Zerr (2 solutions). (7).

Geometry 115. Wm. B. Borgers, H. E. Trefethen. Also two incorrect solutions. (4).

Trigonometry 116. Mrs. Harold Blair, T. M. Blakslee, Lucy T. Dougherty, A. M. Harding, W. L. Malone, H. E. Trefethen, Eugene R. Smith, I. L. Winckler, G. B. M. Zerr. (9).

Applied Mathematics 117. T. M. Blakslee, W. L. Malone, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (5).

Total number of solutions, 40.

PROBLEMS FOR SOLUTION.

Algebra.

123. *Proposed by Gertrude L. Roper, Detroit, Mich.*

A man has a 400 ft. lot facing a north and south street. The north and south lines are 1200 ft. and 1500 ft. respectively. The lot runs to an angling street and measures 500 ft. Where shall he build an east and west line fence so that his two sons may share equally in the estate?

124. *Proposed by Walter L. Brown, Fancher, N. Y.*

A plank 16 ft. long with a weight of 196 lbs. on one end balances across a fulcrum placed one foot from the 196 lb. weight. What is the weight of the plank?

125. A and B entered into partnership and gained $200. Now 6 times A's accumulated stock (capital and profit) was equal to 5 times B's original stock; and 6 times B's profit exceeded A's original stock by $200. Required the original stock of each. *(Wells' University Algebra, 1880, p. 130).* Solve by linear equations.

Geometry.

126. *Proposed by A. W. Rich, Worcester, Mass.*

Given a triangle ABC on whose sides as bases are drawn isosceles triangles whose base angles are 30°. Prove that the triangle formed by the vertices of the isosceles triangles is equilateral.

Trigonometry.

127. *Proposed by W. T. Brewer, Quincy, Ill.*

A man 6 ft. high stands in front of a looking-glass resting on the ground and leaning at an angle of 30° against the wall, from which he is 10 ft. distant. What must be the length of the glass that he may just see his whole person? *(Parkison's Optics, 1870, p. 257.)*

ENGINEERING PROS AND CONS OF THE METRIC SYSTEM.

Some interesting facts were brought out at a meeting of the Society of Engineers in London, June 1, 1908, under the above caption, Arthur H. Allen, A.M.I.E.E., being the chief speaker, and his address being followed by a general discussion. It was the first time a paper on the Metric System had been read before that society, and a majority of the speakers were on the Pro side. Mr. Allen stated that ideas of decimalization of measures originated in England, that James Watt was the first advocate, in 1773; that whenever a Parliamentary Commission had been appointed to look into the case, it had always reported favorably to the adoption of the Metric System; that in 1856 an International Association for Decimalization was formed and now its work is carried on by the Decimal Association; that the movement had not made so great headway in Great Britain, America, or Russia as elsewhere; that the latest country to adopt the system is Denmark, where it will be in use after 1910. He contrasts the English chaos to Metric harmony. The cubic foot of water has been supposed to weigh 1,000 ounces, but recent tests show only 996.6 oz, or 62.228 lb. He mentions the useless labor and loss of time in using the English. "There is so much to be learnt nowadays even to attain the average level of information, that it is madness to waste valuable time at the most receptive age on hack-work of this kind." "There are no fewer than 200 weights in actual use for selling corn." Of the opinions about the hindrance of trade by our system—"so well is this understood by business men, that as long ago as 1900, 40 Chambers of Commerce, 29 Town Councils, 18 Trade Councils, and numerous other bodies had passed resolutions in favor of the adoption of the Metric System." In foreign commerce the difficulty begins at the start. "The sizes of bales, for instance, are given in inches and have to be first reduced to cubic inches, then to cubic feet in order to ascertain the shipping charges at 40 cubic feet to the ton." Regarding screw threads: "Metric micrometers are conveniently made with one revolution per millimeter, reading to $\frac{1}{100}$ mm, but inch micrometers have to be made with 40 revolutions to the inch, and 25 divisions to the circle, or some such awkward arrangement involving much mental effort and liability to error. The $\frac{1}{100}$ mm is a finer and better unit than the $\frac{1}{1000}$ inch, which is 2½ times as coarse." "As for engineering calculations, the advantage is so enormously on the side of the Metric System that it is hardly worth discussing."

In the discussion which followed, the preference was for the $\frac{1}{100}$ mm over $\frac{1}{1000}$ inch, the latter being too large and the $\frac{1}{10000}$ too small. Col. Compton opposed the system, especially for land measurements, which he thought could never be changed, while he acknowledged and deplored the waste of time in schools in learning the present tables. Maj. Hardy declared that decimals were poorly taught in primary schools, though they should be emphasized over common fractions. It was stated that in Switzerland the Metric System, after having been made familiar by compulsion in commerce, had been voluntarily adopted by the people in manufactures.

Mr. Wedekind, educated as an engineer in England, went to a large tool works in Germany where he had to forget all his English tables of measures with their inaccuracies, and was astonished at the ease of working with the new system in contrast to the old where he had "to compute and add such groups as 2 ft., 11 $\frac{13}{16}$ in. and tally them with other similar strings." He went to France, likewise to Spain, where he found the same easy conditions, thus proving the great advantage in using metric measures. Mr. Allen refuted an idea often held that parts of machines made to metric and inch measurements could not be made interchangeable. R. P. W.

ARTICLES IN CURRENT MAGAZINES.

Photo-Era for September: "Associates in Pictorial Photography," Phil M. Riley; "Persulphate vs. Permanganate as the Reversing-Solution for Autochromes," G. E. H. Rawlins; "The Treatment of Incorrect Exposure of Autochromes during Development," A. and L. Lumière and A. Seyewetz; "Cold Development of Sepia Platinum Paper," L. C. Bishop; "Aids to Downhill Perspective," Anthony Guest; "Glycerine Methods of Control in Platinum Printing," Madison Phillips.

Conservation for September: "The Cost of Conservation," by W. J. McGee; "Work on a National Forest (illustrated)," by Charles H. Shinn; "Forest Policy on Pennsylvania," by John L. Strobeck, illustrated; "Nation's Need of Forestry Work," by Mrs. J. E. MacKisson, illustrated.

Physical Review for September: "The Effect of Concentration and Ionization on the Rates of Diffusion of Salts in Aqueous Solution," Raymond Haskell; "The Application of the Ionization from Hot Bodies to Thermometric Work at High Temperatures," O. W. Richardson; "Differential Electric Double Refraction in Carbon Bisulphide," C. F. Hagenow; "Some Studies in Short Duration Phosphorescence," Chan. W. Waggoner.

Scientific American Supplement for September 5: "Physico-Chemistry and Biology," by Earnest Solvay; "The Homes of Mexican Peons," by H. Garlitt; "Modern Physiology," by Professor Frederic Schiller; "The Next Apparition of Halley's Comet," by H. C. Wilson. For September 12: "The Age of the Sun and Earth," by Florian Cajori; "Room Disinfection," by W. B. McLaughlin. For September 19: "The Liquefying of Helium," by Francis Hyndman; "Barley and Its Cultivation," by Professor D. Finlayson; "The Transplanting of Fish," by Hugh M. Smith. For September 26: "Changes in the Earth," by Hon. Robert John Strutt; "The Movement of Plants," by Francis Darwin; "The Problem of the Rotation of Venus," by Otto Hoffmann. For October 3: "Armour-bearing Animals," "Reinforced Concrete Poles," "The Measurement of Ocean Waves," by J. B. Van Brussel; "A Primer of Wood Preservation," by W. F. Sherfesee.

School Review for September: "Industrial and Technical Training in the Secondary Schools and Its Bearing on College-Entrance Requirements," C. R. Mann; "A General View of German Pedagogy for the Benefit of Foreigners. IV," Wilhelm Münch; "Scientific Basis of High School Methods," Charles DeGarmo; "The Relation of the High School Course to the Student's Life Problems," H. B. Wilson.

Physical Review for August: "The Capacity of Paper Condensers and Telephone Cables, with a Note on the Determination of the Specific Inductive Capacity of Dielectrics," Anthony Zeleny and A. P. Andrews; "The Electrical Properties of Silicon. III. The Hall Effect in Silicon at Ordinary and Low Temperatures," Frances G. Wick; "Effect of the Cathode Rays in Changing the Colors of Certain Minerals," C. C. Hutchins; "Liquid Air Above the Critical Temperature," W. P. Bradley, A. W. Browne and C. F. Hale; "The Fluorescence and Magnetic Rotation Spectra of Potassium Vapor," R. W. Wood and T. S. Carter; "The Frequency of the Singing Arc," G. W. Nasmyth; "A Galvanometer Scale for the Direct Reading of Temperatures with Thermo-Electric Couples," A. Zeleny.

Popular Science Monthly for September: "The Botanical Gardens of Ceylon," Professor Francis Ramaley; "The Prehistoric Aborigines of Minnesota and their Migrations," N. H. Winchell; "The Movement Towards 'Physiological' Psychology," Professor R. M. Wenley; "The Practical Value of Pure Science," Professor Thomas Montgomery, Jr.; "The Physique of Scholars, Athletes and the Average Student," Professor D. A. Sargent; "Modern and Early Work upon the Question of Root Excretions," Howard S. Reed; "Silver," Theo F. Van Wagenen.

CENTRAL ASSOCIATION MEETING.

The Central Association of Science and Mathematics Teachers will hold its *Eighth Meeting* on Nov. 27-28, at the Englewood High School, Chicago.

The Executive Committee has been working since last spring and their efforts give promise of yielding the most interesting and valuable program that the association has ever given.

President Chas. S. Howe of the Case School of Applied Science, Cleveland, will give the after-dinner address Friday evening.

There are two general addresses Friday morning, the first one being by Robert K. Duncan, Prof. of Industrial Chemistry, University of Kansas. Subject: "Temporary Industrial Fellowships." Prof. D. O. Barto of the Univ. of Ill. gives the second address.

Among those reading papers or taking part in the discussions are Prof. R. D. Salisbury, Univ. of Chicago; Prof. John F. Woodhull, Teachers' College, New York; Prof. Henry Crew, Northwestern Univ.; State Superintendent H. L. Terry, Madison, Wis.; Dr. J. W. Folsom, Univ. of Ill.; Prof. Dayton C. Miller, Case School, Cleveland; Prof. Mark Jefferson, Ypsilanti, Mich.; Dr. S. C. Davisson, Univ. of Indiana; Dr. Chessin, Washington Univ., St. Louis; Prof. Otis W. Caldwell, Univ. of Chicago; T. W. Galloway, James Millikin Univ.; Prof. Carl Guth, Univ. of Iowa; Prof. R. A. Millikan, Univ. of Chicago; Prof. W. H. Norris, Grinnell, Iowa; Prof. Lynds Jones, Oberlin College; Prof. H. E. Cobb, Lewis Institute, Chicago, and many others.

Each of the five sections is to consider fundamental principles. The Mathematics Section will hear two committee reports, one of which is printed in this number of SCHOOL SCIENCE AND MATHEMATICS.

In Biology, field problems on birds, trees, insects, weeds and fishes are presented with a report on a Biological Creed.

In Earth Science, fundamental problems of Physiography are studied.

In Chemistry, systematization and unification of topics in Chemistry for secondary schools.

In Physics: "Coördination of High School and College Physics," "The Present Status of the New Movement," and a symposium upon "What are the Fundamentals?"

AMENDMENTS TO THE CONSTITUTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

(1) To amend Article V—DUES—to read: "The annual dues of active and associate members shall be two dollars payable at the annual meeting for the following year."

(2) To amend Article V—DUES—to read: "Membership, without the official organ, may be secured by payment of one dollar at the annual meeting."

PROGRAM OF THE ANNUAL MEETING OF THE NORTHERN ILLINOIS TEACHERS' ASSOCIATION.

To be held at Joliet, Illinois, on the 6th and 7th of November, 1908.

GENERAL SESSION: FRIDAY, 9 A. M.

"Moral and Religious Education in the Public Schools."

(*a*) From the standpoint of Psychology, Professor George A. Coe, Northwestern University, Evanston, Ill. Discussion opened by Dr. John Cook, Northern Ill. Normal School, DeKalb, Ill.

(*b*) From the standpoint of Sociology, Professor Edwin D. Starbuck, University of Iowa, Iowa City, Iowa. Discussion opened by Professor T. G. Soares, University of Chicago, Chicago.

President's Address, Superintendent J. N. Adee, Batavia, Ill.

Address, "What Religious Truths may and should be taught in the Public Schools?" President Harry Pratt Judson, University of Chicago, Chicago. Discussion opened by State Superintendent F. G. Blair, Springfield, Illinois.

"The Pedagogy of Morality and Religion as Related to the Periods of Development," Professor W. G. Bagley, University of Illinois, Urbana, Illinois. Discussion opened by Dr. C. W. Votaw, University of Chicago, Chicago.

Discussion of the following resolution:

Resolved, That the minimum annual wages of all qualified teachers in the public schools of Illinois should, in no event, nor under any circumstances be less than $365, and that whenever a school district by taxing itself to the limit authorized by law is unable to pay this amount, the deficit should be supplied by the state or the school district annexed to another district in which the payment of a minimum wage as large as the one specified in this resolution can be paid. Discussion opened by President Alfred Bayliss, Western Normal School, Macomb, Illinois.

HIGH SCHOOL AND GRAMMAR SCHOOL SECTIONS, FRIDAY P. M.

J. Stanley Brown, Chairman.

General Topic, "The Function and Autonomy of the High School."

I. Relative to the Elementary School, Assistant Superintendent J. S. Bryan, St. Louis, Mo.

Discussion, Professor C. A. McMurry, Northern State Normal School. DeKalb, Illinois.

II. Relative to the College, Principal L. W. Smith, High School, Harvey, Illinois.

Discussion, Professor W. Libby, High School Inspector, Northwestern University, Evanston, Illinois.

III. Relative to the High School, President L. C. Lord, State Normal School, Charleston, Illinois.

Discussion, Principal H. N. Loomis, Hyde Park High School, Chicago.

Executive Committee: A. V. GREENMAN, Aurora, Ill.
N. D. GILBERT, DeKalb, Ill.
OTIS W. CALDWELL, Chicago.

PERSONALS.

Giles E. Ripley of Valley City, N. D., goes to the University of Arkansas (Fayetteville) as head of the Department of Physics.

C. E. Haigler of the Michigan College of Mines, Houghton, has been appointed Austin scholar in Physics at Harvard University for this year.

Prof. A. C. Works, a subscriber to SCHOOL SCIENCE AND MATHEMATICS from the first number, and head of the Science Department in Genesee Wesleyan Seminary for over twenty-five years, died in June last. His son succeeds him in the seminary.

B. L. Steele of Marion, Ind., takes Mr. Lynn B. McMullen's place as head of the Physics Department in the Shortridge High School, Indianapolis, Ind.

Miss Effie Graham of the Topeka, Kan., High School, has been delivering an illustrated lecture on "Living Arithmetic" at county institutes in Kansas with great success during the past summer. Miss Graham is also Secretary-Treasurer of the Kansas Association of Mathematics Teachers.

Mr. Lynn B. McMullen, for a number of years the head of the Department of Physics in the Shortridge High School, Indianapolis, becomes head of the Department of Science in the State Normal School, Valley City, North Dakota.

Professor W. Goldthwaite, Associate Editor of this Magazine, formerly professor of geology Northwestern University, becomes head of the Department of Geology in Dartmouth College, Hanover, N. H.

BOOKS RECEIVED.

Laird & Lee's Diary and Time-Saver for 1909. Tenth Annual Edition. Laird & Lee, Chicago. Full black or red leather, gold stamping, gilt edges, vest-pocket size, 25c.

Elementary Principles of Agriculture. A Text-Book for the Common Schools, by A. M. Ferguson and L. L. Lewis. Pp. 304. Price, $1.00 postpaid. 1908. Ferguson Publishing Co., Sherman, Texas.

First Course in Biology, by L. H. Bailey and Walter M. Coleman. Part I, Plant Biology, pp. 204; Part II, Animal Biology, pp. 223; Part III, Human Biology, pp. 164. 1908. New York, The Macmillan Co., price, $1.25.

Inductive Geometry. An Introduction to and a Preparation for the regular text, by Col. C. W. Fowler, Kentucky Military Institute. 3d edition. 1908. Pp. 52. Published by the author. Lynden, Ky.

The New Physics and Its Evolution, by Lucien Poincaré. Pp. 344. 1908. D. Appleton & Co., New York.

The Standard Domestic Science Cook Book, by William H. Lee and Jennie A. Tansey. 536 pp. 16 full page colored plates. Washable cover, $1.75. 1908. Laird & Lee, Chicago.

The Evolution of Forces, by Dr. Gustave Le Bon. Pp. 388. 1908. D. Appleton & Co., New York.

BOOK REVIEWS.

Spectrum Analysis, by John Landauer, LL.D.; Authorized English Edition by J. Bishop Tingle, McMaster University, Toronto; Second Edition, Rewritten. 8vo, ix+236 pages, 49 figures. Cloth, $3.00. John Wiley and Sons, New York.

This being the second edition of this work proves its worth. Justice cannot be done the book in this review. It is a book that every instructor in secondary chemistry and physics should have in his library. It is not an exhaustive treatise on spectrum analysis, but is more especially a guide to those who wish to understand something concerning the scope of and methods of this subject.

One wishing to pursue this subject farther will find the text especially helpful as something over one thousand references are given to those investigations and statements by men who have gone into the subject thoroughly. Chapter I is devoted to a historical introduction; there is given, too, a bibliography of works on spectrum analysis. Chapter II gives a physical review of those properties of light especially appertaining to spectrum analysis. In Chapters III, IV, and V one finds descriptions of spectroscopes of different types, spectroscopic instruments for special and various purposes. Chapter VI treats of the spectra in general; this is followed by a chapter on the spectra of the elements. In chapter VIII the absorption spectra is discussed. Something is said concerning the spectrum of the sun, while the last chapter takes up the spectrum of other celestial bodies. The work closes with a complete index of its contents of 28 pages. C. H. S.

Algebra for Secondary Schools, by E. R. Hedrick, Professor of Mathematics, The University of Missouri. Pp. 421. American Book Co.

This has been a notable period for the production of text-books of elementary algebra. Within the last eighteen months six of these books have been published in the territory of the Central Association of Science and Mathematics Teachers, and for the most part the authors are members of the association. This means better instruction in algebra. In some of these books little or no attempt has been made to combine the old and the new systematically from cover to cover. Professor Hedrick, however, has not only made the attempt but he has accomplished it very skillfully. In the first part of chap. II graphs are used to solve problems as well as to represent equations, and the graphical method is used wherever it is needed as an essential part of algebraic work. With this treatment of the subject pupils should realize the value of graphical methods in solving problems that may come to them in books, laboratories, shops, or factories. Practical problems are well distributed through the book, and while rigorous proofs are not always attempted, the pupils are led to feel the truth of the statements, and they are told when the proofs are not complete. Many of the subjects have been approached from a new point of view, but always by a simple and direct path which can be easily followed. The alert teacher will find many points in this book where he can connect algebra with arithmetic, geometry, and the daily life of the pupils. H. E. C.

North American Trees. Nathaniel Lord Britton, assisted by John Adolph Shafer. Published by Henry Holt & Company. Pages, 894 + x; Figures, 781. Price, 7.00.

The most comprehensive single book about trees yet published in this country recently appeared from the hands of Britton and Shafer. The book is intended to cover those trees growing independently of cultivation north of Mexico and the West Indies, and really does include many trees growing within the last-mentioned countries. Drawings or photographs in connection with each species' description illustrate the foliage, flowers, and fruit. While the number of photographs is not so large as some users of the book may wish, the reviewer desires to call attention to the fact that frequently such drawings or diagrams as are used can present in a very small space certain details that could not be had in a single photograph. This combination of details in a compact diagram is often quite essential to the work of the student. It would have proven helpful to many of those who will use the book if the diagrams and photographs might have been done accompanied by some easily appreciated measuring scale as in "Hough's Handbook of the Trees of the Northern States and Canada," recently reviewed in this magazine. (See SCHOOL SCIENCE AND MATHEMATICS, 8:437.) Knowledge of the size of detailed structures is often a determining factor in an identification, and although this item may usually be given in the word description, it is more graphic and accessible to have the size indicated in the background of the illustration or in some accompanying structure. About one half the illustrations are new, the rest having been taken from Britton and Brown's "Flora of the Northern States and Canada," and other sources.

It is quite evident that there is a rapidly increasing number of people of semi-scientific turn of mind who are interested in trees, and to them as well as to botanists and dendrologists this book will be most welome. Rendering it possible, as the book does, for the amateur to become acquainted with the trees in his locality, it should meet with extensive use, and prove an effective means of enhancing the growth of the recently revived spirit of natural history. O. W. C.

Synthetic Inorganic Chemistry, a laboratory course for first year college students, by Arthur A. Blanchard, Ph.D., Assistant Professor of Inorganic Chemistry at the Massachusetts Institute of Technology. New York, John Wiley & Sons; London, Chapman & Hall, Limited. 1908. 12mo, viii + 90 pages. Cloth. $1.00 net (4/6 net).

This book was prepared to serve as a guide for laboratory work in Inorganic Chemistry during the second term of the first year. The thirty-seven well chosen exercises are grouped according to the periodic system. The notes for each exercise are divided into three parts: I. A discussion of the object of the exercise, with an outline of the principle of the method and the reasons for the steps involved. II. Working directions which are quite explicit and should if followed carefully result in obtaining a satisfactory product. III. Questions for study which involve additional laboratory experiments, the consulting of text-books, and original reasoning.

At the end of each group of exercises there is a set of general study questions, and the arrangement of the exercises in groups is such as to bring out the relationships shown in the periodic classification of the elements.

The author assumes that the student has an elementary knowledge of the electrolytic dissociation theory and of the principle of mass action. Advantages claimed by the author for a course of this kind are:

1. The sequence of the exercises may follow that of the lectures.
2. Very varied types of chemical change are illustrated, both those in the furnace and those in solution.
3. The danger of the work becoming a mechanical following of directions is reduced by the introduction of study questions and experiments with each exercise.
4. In its effect in awakening the student's interest this line of work has proved particularly successful, the knowledge thus gradually absorbed is more definite and less easily forgotten than when the laboratory work consists of a large number of test tube reactions. A. L. S.

A Text-Book in Physics, by William M. Mumper, Professor of Physics in the State Normal and Model Schools of Trenton, N. J. Pp. 401. American Book Co.

This text differs from those of the Millikan and Gale type in that "few photographs or pictures of apparatus are used." Little is put in for entertainment and no description of experiments—the use of a separate laboratory manual being presupposed.

Many diagrams are used. These are well selected and helpful. The style is clear; there seem to be few paragraphs that can not be readily grasped by the average pupil. There is a good assortment of problems in which the physical rather than the mathematical thought is most prominent.

Two hundred and thirty-six pp. are given to Mechanics and Heat, 22 to Sound, 99 to Magnetism and Electricity, and 44 to Light.

Very little historical matter is given. In electricity, only the simplest devices are described, emphasis being placed upon principles rather than their application in machines.

This text is designed to be supplemented by a good laboratory, suggestive experiments, and many illustrative devices. W. E. T.

The next meeting of the Department of Superintendence of the National Education Association will be held in Chicago February 23, 24 and 25, 1909.

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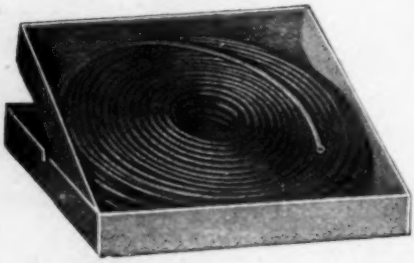

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